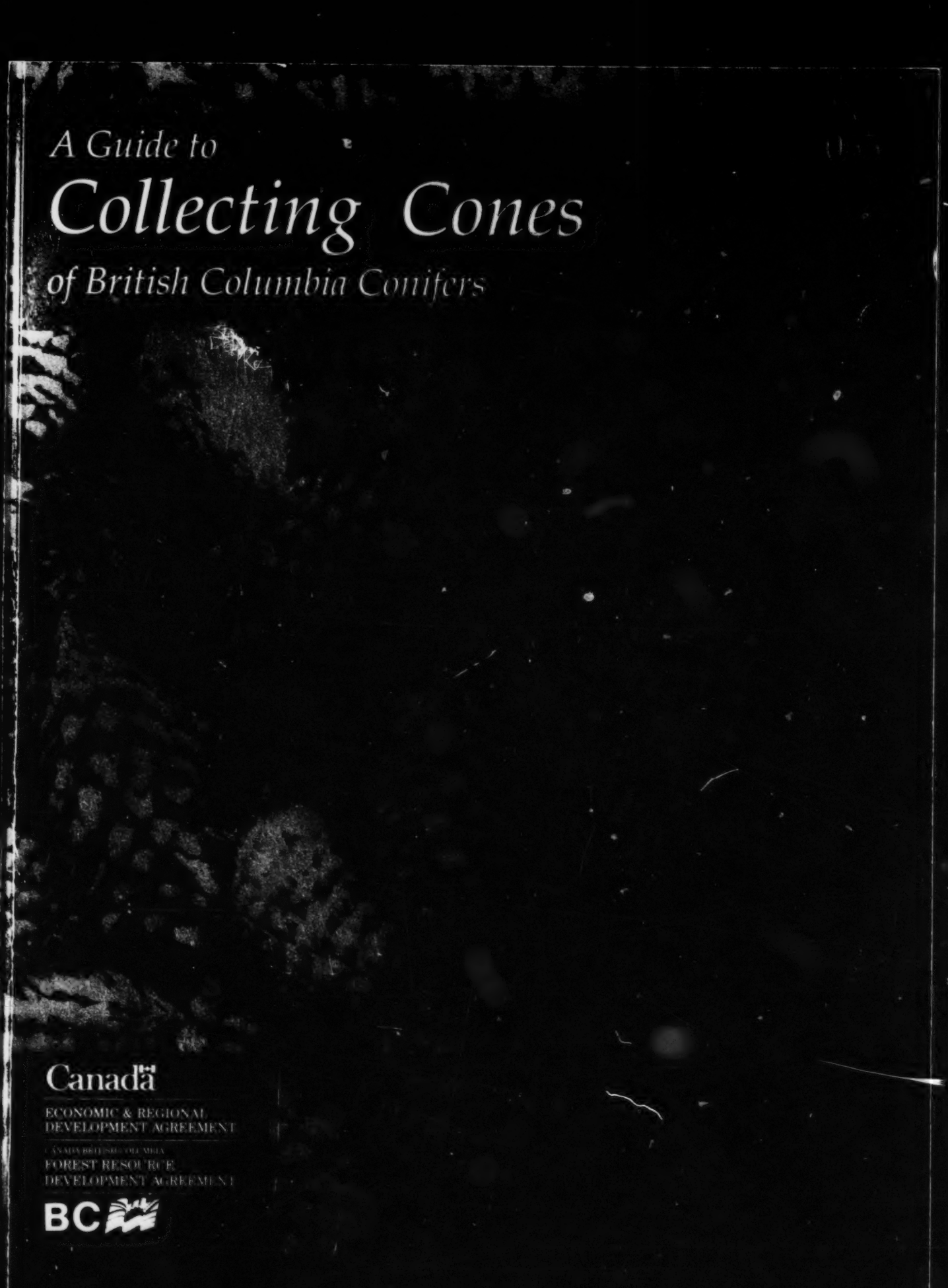

A Guide to Collecting Cones of British Columbia Conifers

Canada

ECONOMIC & REGIONAL DEVELOPMENT AGREEMENT

CANADA-BRITISH COLUMBIA FOREST RESOURCE DEVELOPMENT AGREEMENT

BC

A Guide to Collecting Cones of British Columbia Conifers

by
R.D. Eremko[1], D.G.W. Edwards[2] and D. Wallinger[3]

[1] Silvastream Consulting Ltd.
2640 Valleyview Drive
Kamloops, B.C. V2C 4E5

[2] Forestry Canada
506 W. Burnside Road
Victoria, B.C. V8Z 1M5

[3] formerly with:
British Columbia Forest Service
Silviculture Branch
31 Bastion Square
Victoria, B.C. V8W 3E7

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For further information about the Canada-British Columbia Forest Resource Development Agreement, contact:

Forestry Canada
Pacific Forestry Centre
506 West Burnside Road
Victoria, B.C. V8Z 1M5
(604) 388-0600

or

B.C. Ministry of Forests
Research Branch
31 Bastion Square
Victoria, B.C. V8W 3E7
(604) 387-6719

FOREWORD

Acquiring adequate quantities of high quality seeds is the first step in meeting the reforestation needs of the province. As these needs continue to grow, it is essential that silviculture staff have a sound understanding of the various facets of tree seed collection and related aspects of seed production and processing.

Since cone collections are not necessarily an annual event, field and laboratory personnel - in particular those individuals who oversee and supervise seed collections - are often assisted by updated training in the procedures and techniques required. To this end, a Guideline to Collecting Cones of B.C. Conifers (British Columbia Forest Service/Canadian Forestry Service, Joint Report No. 3) was published in 1976. Primarily addressed to B.C. Forest Service personnel, the guide proved to be of interest to foresters and technical staff over a wide geographical area, and has been used in various parts of the United States, Europe, and several other countries. Since its publication more than 12 years ago, new information has become available, increasing the understanding of seed biology, of the impediments to cone and seed production (notably insects and diseases), and of collection methodologies. Also, the rules and regulations governing reforestation practices in British Columbia have recently been revised. It was deemed timely, therefore, that a thorough revision of the publication be undertaken.

Information presented in this new publication, coupled with knowledge that can be gained from cone and seed workshops, is intended to assist field silviculturists, planners and managers of the province's expanding reforestation program. The revised *Guide to Collecting Cones of B.C. Conifers* was funded in part by the Canada/British Columbia Forest Resource Development Agreement (FRDA), Extension, Demonstration, Research and Development Sub-program, and has been developed cooperatively with federal, provincial, and private-sector cone and seed specialists. We trust that it will stand as a worthy example of what can be achieved when agencies cooperatively apply their resources toward a common goal.

John Cuthbert, Chief Forester
British Columbia Forest Service
Victoria, B.C.

Dr. T. John Drew, Director General
Pacific and Yukon Region
Forestry Canada
Victoria, B.C.

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The authors are also deeply indebted to all the reforestation planners, cone collectors, seed processors, and users, from government, industry and educational institutions, who used the original publication and replied to the user survey. User support of the revisions of this guide is greatly appreciated.

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1 INTRODUCTION

The collection of adequate volumes of cones yielding high quality seeds is essential to British Columbia's reforestation program. This involves not only locating and evaluating collectable crops, but also managing personnel and equipment efficiently and safely. Once collected, cones must be handled in a manner which ensures that seed quality does not deteriorate in temporary storage or during transport to the extraction facility.

This guide includes a concise description of cone and seed development, an overview of the collection operation, and detailed summaries of specific cone and seed production and collection characteristics of British Columbia conifers. Quality standards are also recommended. While the focus is on natural stands, which are expected to provide the bulk of the seeds for the province's reforestation program in the next decade, many of the concepts discussed are applicable to seeds derived from other sources. For the user's convenience, references providing detailed discussions of specific topics outlined in the text are summarized at the end of each section. Technical terms are defined in the glossary (Appendix 1).

Like the original *Guideline to Collecting Cones of B.C. Conifers*, published in 1976, this revision is meant to be a guide only. It is not meant to replace local experience or to impose static prescriptions. The information is current as of the date of publication and should be updated as new tree seed research results become available and as provincial regulations change. The format of this publication provides ample margins for such revisions to be noted as they occur. Readers are also encouraged to forward any errors or omissions to the Silviculture Branch of the B.C. Forest Service (BCFS) for inclusion in future updates.

2 CONE AND SEED DEVELOPMENT

Douglas-fir pollen cones

A mature Douglas-fir cone

A Douglas-fir seed cone

Douglas-fir vegetative and reproductive buds

A heavy interior spruce cone crop

2 Cone and Seed Development

The formation, development and magnitude of cone crops depends on a series of complex, interrelated biological processes and environmental conditions. In conifers, cone and seed production involves four principal stages: the formation of reproductive buds, development of pollen and seed cones, pollination and fertilization, and maturation. The entire process referred to as the reproductive cycle varies from 17 to 28 months, depending on species.

This discussion of cone and seed development is a synthesis of work by many authors, and readers are encouraged to refer to the sources cited at the end of this section for additional information.

Bud Initiation

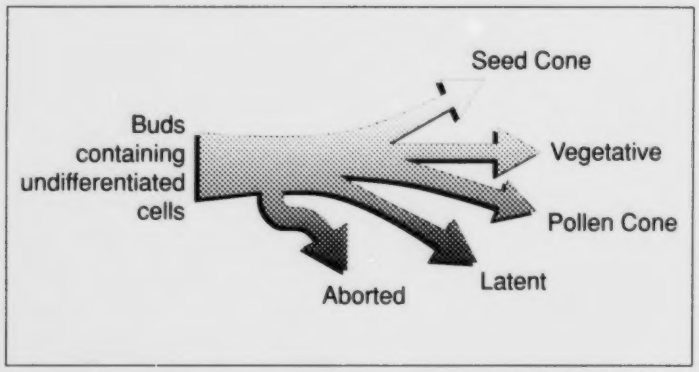


FIGURE 1. Possible pathways of bud development

In early spring, vegetative buds "burst" and the compressed shoot axes elongate into new shoots. During the earliest stages of development, the new buds that form along the elongating shoot contain masses of undifferentiated cells lacking structure and function. Differentiation of these cells takes place throughout the first growing season, i.e. the growing season before the year in which cones or flowers appear. Since differentiation may result in vegetative, reproductive, or latent structures (Figure 1), this period is critical in cone crop determination.

Bud initiation occurs annually, but the development of these buds into reproductive structures depends on environmental conditions, growth regulators, and position on the new branch. Buds are situated terminally, subterminally, and laterally along the branch (Figure 2). Terminal buds generally contain vegetative structures, whereas lateral buds may develop into either latent vegetative buds or reproductive buds. Most often, reproductive buds near the base of the shoot become pollen cones, while those nearer to the terminal develop into seed cones. Latent buds generally develop into new shoots, and are stimulated by removal of the terminal bud. Buds may also abort. Early bud abortion is most common near the base of the branch, the area in which pollen cones generally develop.

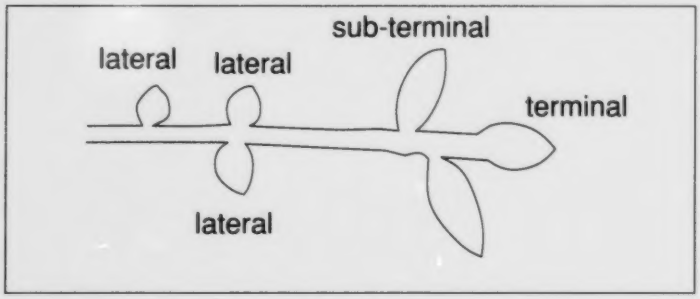


FIGURE 2. Position of buds on a branch

By mid-summer, reproductive and vegetative buds can be distinguished by anatomical differences. Vegetative buds contain a spiral series of leaf primordia whereas reproductive buds contain miniature pollen cones or seed cones. However, it is difficult to recognize the structures within reproductive buds until February or March of the following year, even with a hand lens.

Pollen Cone and Seed Cone Development

Vegetative and reproductive buds become dormant in late summer or early fall and, through winter dormancy, are protected by tightly overlapping scales, wax, and/or hair. Buds burst in the following spring, and shoot and reproductive structure development continues.

Pollen cones (page 3) consist of an axis or stem bearing spirally arranged scales (microsporophylls), each of which supports two pollen sacs (microsporangia). In pollen cones, meiotic cell division takes place within the pollen sacs, producing a sphere of four microspores. The microspores develop further and are then referred to as pollen grains. The pollen grains subsequently undergo several mitotic divisions before being shed.

Seed cones (page 3) are similar in structure to pollen cones in that they consist of an axis supporting spirally arranged bracts (megasporophylls). However, in seed cones an ovuliferous scale is also attached to the axis at the base of each bract. Each ovuliferous scale supports two ovules (megasporangia) on its upper surface, both of which could potentially develop into a seed. Each ovule is surrounded by a covering called the integument which later becomes the seedcoat. Cells undergo meiotic division in the central tissue of the ovule, resulting in four cells (megaspores), each of which has half the original number of chromosomes. Generally, as the ovule matures, only one megaspore remains functional; the others degenerate.

Pollination and Fertilization

As the spring weather warms, the development of pollen cones and seed cones reaches completion. The mostly pendant pollen cones elongate rapidly causing the enlarged pollen sacs to separate. The sacs dry out, split open, and release the pollen grains, which are then transported by air currents to the seed cones. In years of heavy pollen production, pollen may be visible on the surface of ponds or as yellow clouds. More or less simultaneously the seed cones, which are mostly upright on the shoot, also elongate. This elongation causes the bracts to separate and reflex open, and the seed cones become receptive to the entry of pollen grains. The pollen grains drift down among the erect scales of the seed cone, towards the ovules at the base, completing the process called pollination. Pollen grain shape varies with species, as does the mechanism by which pollen is drawn towards the ovule. Seed cones may remain receptive to pollen for up to 3 weeks, depending on the species and weather conditions.

Once pollen reaches the receptive ovules, the cone scales and bracts close rapidly. In most species, with the exception of the true firs, the seed cones become pendant on the branch. This signals the completion of pollination. Within the seed cones the pollen grains germinate, each grain producing a long tube. One pollen tube penetrates an ovule. Fertilization occurs when a single sperm cell, produced by cell division within the pollen grain, fuses with an egg cell, thereby doubling the chromosome number. The number of chromosomes (2N) is now again characteristic of the species. The time between the onset of pollen tube growth and fertilization varies with species, from 1 week in Douglas-fir to 1 year in pines.

The fertilized egg divides and differentiates to form a recognizable embryo. The embryo is surrounded by food storage tissue and a protective covering, or seedcoat (Figure 3).

In many species, seeds may reach full size even when pollination does not occur. Without fertilization, however, such seeds will not contain embryos. The exception to this is found in pines, in which the entrance of pollen into the seed cone is essential for further development; without pollen, ovules will not develop into seeds.

Cone and Seed Maturation

Seed maturation involves an increase in carbohydrates, nitrogenous compounds, fats, and organic acids, and a decrease in moisture content. As the embryo matures, it fills the embryonic cavity and develops cotyledons and root and shoot apices. The food storage tissue becomes firm and opaque. (This tissue is correctly called the megametophyte, but it is more commonly referred to as "endosperm." This tissue may form in conifers even though fertilization does not take place. In angiosperms, true endosperm forms as the result of fertilization.) The moisture content of both the seed and the cone decreases, causing the seed and seedwing to separate from the cone scale. Continued moisture loss, which is an essential part of the maturation process, results in separation and reflexing of the cone scales, allowing the seeds to be released. Seeds are said to be mature when they have the capability of germinating and they can be stored successfully.

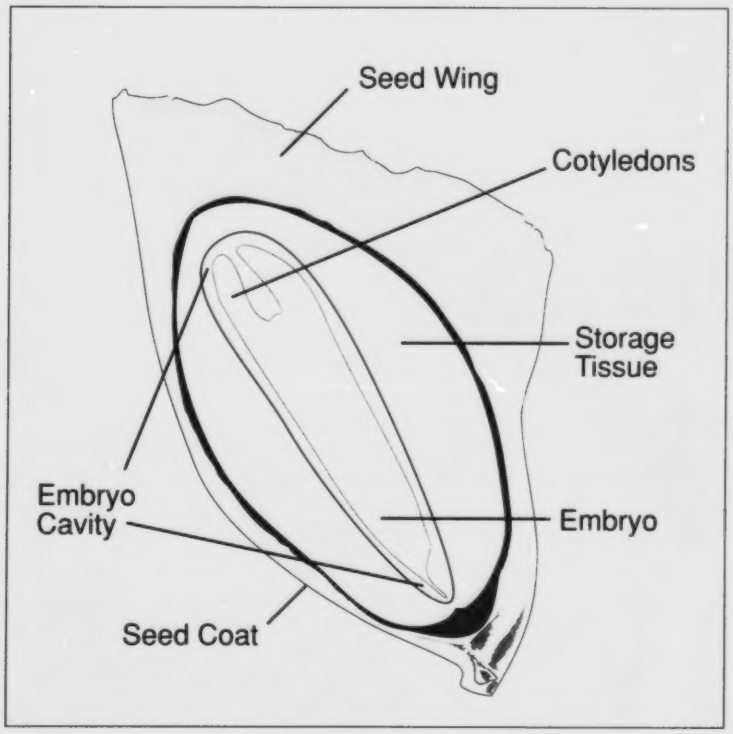


FIGURE 3. Diagrammatic representation of a mature coniferous seed

In the field, maturity is assessed by observation of recognizable changes in the physical characteristics of cones and seeds, including seed and seedwing colour, embryo elongation, and changes in storage tissue condition. Field procedures for assessing cone and seed maturity are described in Section 3.

The time of seed maturation varies between species, individual trees, locations, and crop years, but in most species, seed dispersal generally begins at or shortly after maturation. The precise timing of seed release depends to a large extent on prevailing weather conditions. Cone scales and bracts open in a response to low atmospheric humidity and warm temperatures; they tend to stay closed in cool, moist air. The duration of seedfall varies between species. The cones of true firs disintegrate, leaving only the cone axis (or spike) on the tree. In some species, such as Pacific silver fir (or amabilis fir), the scales become greatly distorted, tearing away from the axis as the cones dry out. Thus, the seeds of this species tend to shed early and rapidly. For grand fir and subalpine fir, some wind action or other branch movement is required to disturb the cone. Consequently, some seeds may remain attached to the axis and may gradually disperse throughout the winter. The bulk of the seeds, however, fall very rapidly once the cone has matured. Seedfall in western larch may also continue into winter since the cones often open and rapidly reclose several times in accordance with changing weather patterns. Serotinous lodgepole pine cones may remain closed for years after seeds have matured; under field conditions, lodgepole pine seeds are not released until the cones have been subjected to high temperatures, generally through fire. However, not all

lodgepole pine cones are serotinous.

The timing of seed collection and the care with which it is carried out directly and measurably influence the quality and costs of subsequent seedling production. Understanding cone and seed development and seed maturity is essential for successful cone collection management. In all species, the degree of maturity achieved before collection affects seed germination, seed yield, susceptibility to handling damage, and longevity in storage. Cones collected prematurely may yield seeds with reduced viability and germinative vigour. The high moisture content characteristic of immature collections may make seeds susceptible to physical damage during transport, extraction, and storage. The importance of understanding the biological characteristics of seed maturity cannot be overstated.

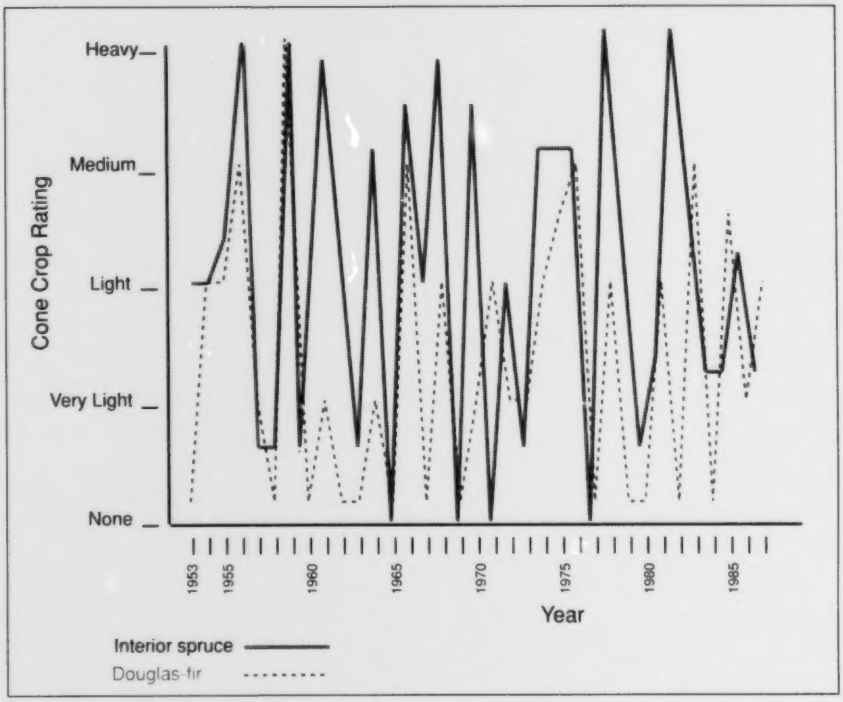


FIGURE 4. Coastal Douglas-fir and interior spruce cone crop ratings for the years 1953 to 1987

Factors Influencing Cone and Seed Development

Cone and seed crops do not normally occur annually. In most conifers, cone crops occur periodically, governed by the biological characteristics of individual species and by external conditions such as weather, insects, disease, and predation by birds and mammals. The annual variation in cone crop production, or crop periodicity, for coastal Douglas-fir and interior spruce is illustrated in Figure 4. The periodicities of individual species found in British Columbia are cited in Section 5.

The periodicity of cone production in a particular species depends on the length of that species' reproductive cycle. For British Columbia conifers, three major types of cycles can be recognized. In the first type, which includes white and other spruces, Douglas-fir, and western hemlock, buds are initiated in early summer and development continues until the fall, when the buds become dormant. Growth resumes the following spring, when pollination is quickly followed by fertilization. Subsequent development is rapid and seeds mature by the fall of the second growing season. This reproductive cycle is usually completed in about 17 months (Figure 5).

The second type of reproductive cycle occurs in pines and requires 26 months for completion (Figure 5). Once pollen tubes and ovules have partially formed, development in the second growing season stops. Fertilization occurs in the spring of the third growing season, and seeds mature by the fall.

A third type of reproductive cycle occurs in yellow-cedar. In this species the reproductive cycle begins in the same manner as the first cycle described for white spruce, Douglas-fir, etc., through to the summer of the second growing season. At this time, seed development stops and the fertilized ovules overwinter in a dormant state. Growth resumes in the spring of the third season, extending the length of this reproductive cycle to approximately 28 months (Figure 5).

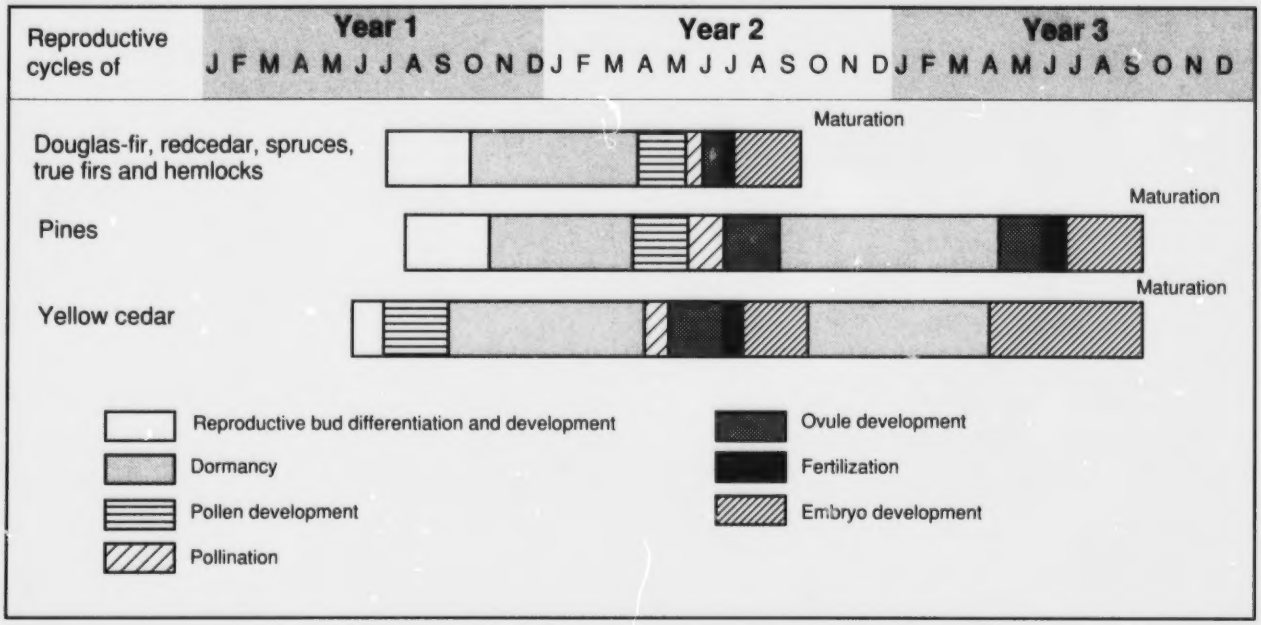

Reproductive cycles of
Year 1
Year 2
Year 3
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
Douglas-fir, redcedar, spruces, true firs and hemlocks
Maturation
Pines
Maturation
Yellow cedar
Maturation
Reproductive bud differentiation and development
Dormancy
Pollen development
Pollination
Ovule development
Fertilization
Embryo development

FIGURE 5. Three major reproductive cycles found in British Columbia conifers

Further variation in the production of yearly crops results from the negative influence that developing crops have on subsequent crops. For example, in spruce, western hemlock, and western redcedar, where reproductive buds are borne mainly at shoot terminals, cone production in the year following a good crop may be limited by the lack of new vegetative shoots on which reproductive buds could form. In true firs and Douglas-fir, where flowers are produced on the previous year's shoots, the drain on carbohydrates necessary to support a heavy crop may limit shoot growth in that crop year. Consequently, little space will be available on these shorter shoots for flower initiation the following year.

Some trees, either individually or in stands, produce very few, or no cones throughout their life time, a reflection of their genetic make-up. However, even for trees that frequently produce many cones, the size of the cone crop will vary annually according to environmental factors. Thus, the amount of cones produced in any given year can vary for numerous reasons among individual trees, among stands, and between geographic locations. A heavy cone crop in one species may be accompanied by a light crop (or no crop) in another species growing in the same area.

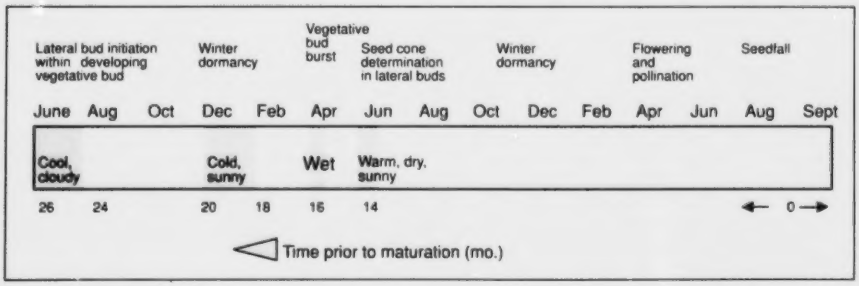

Lateral bud initiation within developing vegetative bud
Winter dormancy
Vegetative bud burst
Seed cone determination in lateral buds
Winter dormancy
Flowering and pollination
Seedfall
June Aug Oct Dec Feb Apr Jun Aug Oct Dec Feb Apr Jun Aug Sept
Cool, cloudy
Cold, sunny
Wet
Warm, dry, sunny
26 24 20 18 16 14 0
Time prior to maturation (mo.)

FIGURE 6. Climatic conditions required for cone crop production in Douglas-fir

The influence of weather conditions may be cumulative, spanning a number of years (Figure 6). In Douglas-fir and grand fir, a cool, cloudy summer 26 - 24 months before crop maturation appears to be a prerequisite for abundant lateral bud initiation. These conditions must be followed by cold, sunny weather through the winter (20 - 18 months prior to maturation), a wet April (16 months in advance) to promote lateral bud determination, and then a warm, dry, sunny June before pollination

(14 months before maturation). The importance of dry summers to floral initiation has also been demonstrated in other species, such as spruce, larch, and ponderosa pine.

Moisture stress may also enhance seed cone initiation in Douglas-fir, grand fir, and white spruce. In western white pine, positive correlations have been found between cone production and a warm, possibly wet, fall in the year of bud initiation, rain following pollination, a second warm fall, and a warm, dry spring in the crop year.

In the year of pollination, cold weather may result in the loss of pollen cones in spruce and, when combined with moisture stress, may prevent pollen development. Wet weather reduces both the quantity and viability of white spruce and ponderosa pine pollen, and reduces pollen dispersal in general. Low temperatures following pollination commonly cause cones to abort. In extremely cold weather, frost may kill pollen and ovules, leaving no external signs of injury.

Cone loss may also occur after fertilization, but such losses are thought to be uncommon. By this stage of development, competition for nutrients is greatly reduced, because the seedcoat is already well developed and the seedwing has usually separated from the ovuliferous scale, breaking the vascular connections between the seed and cone.

In species such as Douglas-fir, pines, and spruce, embryos may degenerate as a result of self-pollination. In the true firs, self-pollination results in low embryo viability.

Feeding by birds and mammals may cause losses of mature cones and seeds. The greatest predation losses are generally to squirrels, which collect and cache large quantities of cones for winter food. Mature seeds also provide food for chipmunks and birds such as Clark's nutcracker and crossbills. Table 1 shows a summary of predispersal cone and seed predation by mammals and birds found in British Columbia.

TABLE 1. A summary of predispersal cone and seed predators found in B.C.

Predator	Tree species used	Method of seed use
Hairy woodpecker (*Picoides villosus*)	pines	adults and young eat seed extracted from closed and open cones
Clark's nutcracker (*Nucifraga columbiana*)	Douglas-fir and pines	seeds, extracted from both closed and open cones, are cached and subsequently used as food by adults and young
Red crossbill and white-winged crossbill (*Loxia curvirostra & L. leucoptera*)	Douglas-fir, hemlock, larch, pines, spruce and true firs	adults and young eat seeds extracted from closed and open cones
Red squirrel (*Tamiasciurus hudsonicus*)	Douglas-fir, hemlock, larch, pines, spruce and true firs	animals cache, and subsequently feed on, whole closed cones
Chipmunk (*Eutamius*)	Douglas-fir, hemlock, larch, pines, spruce and true firs	animals cache, and subsequently eat, seeds from closed or open cones

Cone crops may also be destroyed or damaged by insects and diseases. Damage may occur at all stages of cone and seed development, and it varies among geographic locations and from one year to the next. If insects lay eggs, the larvae may feed in reproductive buds, cones, or seeds. Insects that attack reproductive buds and cones can cause bud, cone, and seed abortion, as well as other visible deformities. Some insects that attack developing seeds may leave no external evidence of their activity. The size of insect populations is often correlated with the availability of food. Thus, if a second good crop follows an earlier crop, the insect population that developed during the first crop may increase dramatically in relation to the food supply of the second crop, and can cause severe losses. When a poor crop follows a good one, the insect population has a small (or no) food supply, and its size decreases, sometimes to near extinction. The next crop (or two) may then be relatively insect-free. In general, cone and seed insects affecting British Columbia conifers have completed feeding by late summer or early fall (i.e., before cone collection). At this time the larvae either emerge or pupate in the cone axis or in the seeds. As a result, further insect damage rarely occurs after cone harvest.

In addition to insect attacks, various diseases can affect cone and seed production, causing post-fertilization abortion or abnormal germination. Specific pests affecting cones and seeds of British Columbia conifers are identified in Section 5 and described in Appendix 2. A summary of these pests and the damage they cause is provided in Table 2. Readers are also referred to the sources cited at the end of this section for detailed discussions of cone and seed insects and diseases.

Man may also impede cone and seed crop development by collecting cones prematurely. This interrupts the maturation process, often resulting in seed extraction difficulties leading to reduced seed yield and seed quality. Immature seeds usually germinate poorly, can damage during processing, and may deteriorate rapidly when stored. Seedlings produced from immature seeds often grow poorly in the nursery. All of these factors increase costs - not only costs of the seeds themselves, but also the costs of utilizing the seeds. Consequently, proper planning, crop monitoring, and appropriate collection and handling techniques are of paramount importance in obtaining high quality seeds.

Sources of Cone and Seed Crop Development Information

Topic	Sources
Cone and seed biology	Alden 1985; Allen and Owens 1972; Dobbs *et al.*1976; Edwards 1981; Eis and Craigdallie 1983; Eremko *et al.*, 1989; Huber 1981; Owens 1986; Owens and Blake 1985; Owens and Molder 1984a-d; Puritch and Vyse 1977; Schopmeyer 1974
Cone serotiny	Lotan 1973
Factors influencing cone and seed development	Edwards 1986; Eis 1973a; Halvorson 1986; Hedlin 1974; Hedlin *et al.*1980; Miller 1986; Owens 1986; D. Ruth, pers. comm., 1988, Forestry Canada (formerly the Canadian Forestry Service), Pacific Forestry Centre, Victoria, B.C.; Sutherland *et al.*1987

TABLE 2. Major cone and seed pests (Hedin 1974; Hedin *et al.* 1980; and Sutherland *et al.* 1987)

Pest [2]	Conifers affected [1]											
	Pines:				Spruces:			True Firs:				
	Douglas-fir (Fd)	Lodgepole (Pl)	Ponderosa (Py)	Western white (Pw)	Black (Sb)	Interior (Sx)	Sitka (Ss)	Grand (Bg)	Pacific silver (Ba)	Subalpine (Bl)	Western hemlock (Hw)	Western redcedar (Cw)
Insects:												
Barbara spp. (cone moths)	C,S							C,S				
Camptomyia pseudotsuga (cone scale midge)	C											
Choristoneura occidentalis (western S budworm)	C, F											
Conophthorus monticolae (Pw cone beetle)				C,S								
Contarinia oregonensis (Fd cone gall midge)	C,S											
Contarinia washingtonensis (Fd cone scale midge)	C											
Cydia piperana (Py cone moth)			C,S									
Cydia strobilella (S seedworm)					C,S		C,S					
Dasineura abiesemia (B cone seed midge)								S	S	S		
Dasineura canadensis (S cone gall midge)						C						
Dasineura rachiphaga (S cone axis midge)					C		C					
Dioryctria abietivorella (coneworm)	C,S		C,S	C,S	C,S							
Dioryctria auranticella (coneworm)			C,S									
Earomyia abietum (cone maggot)								C,S	C,S			
Earomyia aquilonia (cone maggot)											C,S	
Ernobius punctulatus (Fd cone beetle)	C,S											
Eucosma recissoriana (Pl cone moth)		C,S		C,S								
Lasiomma anthracina (spiral S cone borer)					C,S	C,S	C,S					
Leptoglossus occidentalis (cone bug)	S	S	S	S				S				
Mayetiola carpophaga (S seed midge)						S						
Mayetiola thujae (Cw cone midge)												C,S
Megastigmus lasiocarpae (seed chalcid)									S	S		
Megastigmus piceae (seed chalcid)						S						
Megastigmus pinus (seed chalcid)								S	S	S		
Megastigmus spermatrophus (seed chalcid)	S											
Megastigmus tsugae (seed chalcid)											S	
Pityophthorus orarius (Fd twig mining beetle)	T											
Resseliella sps. (cone scale midge)			C					C				
Diseases:												
Caloscypha fulgens (seed or cold fungus)	S					S	S	S				
Chrysomyxa monesis (coastal spruce cone rust)							C					
Chrysomyxa pirolata (inland spruce cone rust)						C	C					

1 Pests affecting specific conifers are also cited in Section 7 of this guide.

2 Characteristics of, and damage caused by, specific pests are summarized in Appendix 3.

Structure affected: C= cones, F= flowers and conelets, S= seeds, T= twigs.

Note: No major pest damage has been identified in the cones and seeds of native tree species not included in this table.

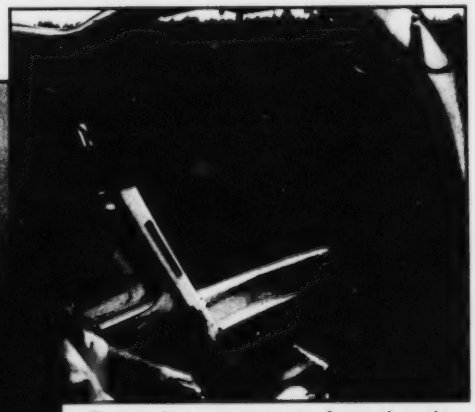
3 COLLECTION PLANNING

Cone collection planning

Collecting cone samples

Cone and seed evaluation

Sectioned Sitka spruce vegetative and reproductive buds



Surveying cone crops from the air

3 Collection Planning

As a result of cone crop periodicity, the procurement of an adequate supply of seeds from natural stands during good crop years is an important component of the provincial reforestation program. Organization of this effort involves a considerable amount of advance planning on the part of the Forest Service, forest companies holding major forest tenures, and private forest land owners. Planning and collection will be greatly facilitated by co-operation among all agencies. Collection planning involves the determination of long-term seed requirements, the establishment of cone collection quotas, crop monitoring, the selection of actual collection areas, and pre-collection organization. In addition to collections from natural stands, seeds are also obtained from stands reserved specifically for seed production, and from seed orchards.

Collection Requirements

The first step in the development of any cone and seed collection program is to determine the amount of seeds, by species and provenance, required to meet reforestation needs over a given planning period. In British Columbia, the usual goal is to maintain a 10-year supply of seeds in storage at all times.

It is important not only to secure an adequate supply of seeds, but also to plan for the collection of future cone crops. For example, Table 3 identifies the volume of cones required to replace the seeds of various species sown in nurseries from 1983 to 1987. Of the approximately 19 000 hectolitres (hl) used, 40% was lodgepole pine, 28% Douglas-fir, 21% interior spruce, and 5% Pacific silver fir. Over this same 5-year period, a total of 27 266 hl were actually collected, of which 44% was lodgepole pine, 31% interior spruce, and 18% Douglas-fir. The overall result is a provincial deficit of Douglas-fir seeds. The deficit was filled by seeds collected in preceding years, but this example clearly demonstrates the need for long-range planning to ensure a continuous seed supply during poor crop years. Seed supplies for minor species should not be ignored, since provincial seed deficits may exist for many of these species. The substantial cone requirements for the provincial reforestation program, even over a 5-year period, underscores the importance of collecting ample supplies.

To identify areas from which seeds need to be collected, the province has been divided into seed planning zones (Figure 7). These zones represent broad climatic regions which follow, for the most part, the climatic region boundaries defined in the biogeoclimatic classification of British Columbia. Within each seed planning zone, transfer rules describe the maximum movement from the original seed source in which seedlings of a given species can be expected to maintain full adaptability. The transfer rules are currently under review and B.C. Forest Service Silviculture staff should be consulted for the latest information. In lieu of evidence to the contrary, it is safe to assume that trees are best adapted to their local environment.

Seed planning zones and transfer rules are used in the annual estimation of seedling requirements. The estimated numbers of seedlings of various species and provenances required by the Crown, forest licensees, and, in some cases, private forest land owners, are then used to calculate the weight of seeds required to meet projected needs. Seedling requirements are then compared to the potential number of seedlings available from seeds in storage for the same species and provenance,

Species	Volume of cones collected (Hl)						Volume of cones required to replace seeds sown (Hl)						Bal. over 5 yr. per. (Hl)
	1983	1984	1985	1986	1987	5 Year Total	1983	1984	1985	1986	1987	5 Year Total	
Cedars:													
western red (Cw)*	53	0	41	77	0	171	12	16	24	31	35	118	53
yellow (Yc)	2	0	34	0	0	36	5	3	5	2	4	19	17
Douglas-fir(Fd)*	1063	73	1513	655	1505	4809	821	935	1059	1573	1032	5420	-611
Hemlocks:													
mountain (Hm)	1	0	0	0	0	1	2	3	1	1	2	9	-8
western (Hw)*	7	0	1	8	14	30	19	28	24	30	27	128	-98
Larches:													
tamarack (Lt)	0	0	0	0	0	0	0	0	0	0	0	0	0
western (Lw)	21	16	0	0	108	145	25	23	15	40	25	128	17
Pines:													
lodgepole (Pl)*	1093	1764	3985	1907	3231	11,980	1158	1002	1349	2305	1828	7642	4338
ponderosa (Py)	38	0	33	0	18	89	11	7	33	18	21	90	-1
western white (Pw)	5	0	348	44	0	397	7	15	41	7	71	141	256
True firs:													
grand (Bg)	30	0	41	1	0	72	19	8	14	13	16	70	2
Pacific silver (Ba)†	300	0	202	298	77	877	132	0	317	297	255	1001	-124
subalpine (Bl)	0	0	0	110	0	10	2	112	0	0	1	115	-5
Spruces:													
interior (Si)*	5803	0	1220	1172	252	8447	660	658	744	1068	827	3957	4490
Sitka (Ss)*	55	22	0	32	13	102	23	29	33	45	34	164	-62
Totals	8471	1855	7418	4304	5218	27266	2896	2839	3659	5430	4178	19002	

* Includes seed orchard collections
† Also know as amabilis fir

Note: Values are rounded to the nearest whole number.

TABLE 3. Five-year seed balances

tabulated in the provincial Tree Seed Register (Figure 8). Anticipated production from seed orchards should also be considered. Any difference between requirements and availability indicates where and for which species a shortage may occur during the planning period. The number of years in the planning period will vary with species' periodicity and seed storage life. The volume of cones required to fill anticipated deficits should then be calculated, and the search for crops concentrated in those areas where shortages are indicated. It is generally necessary to collect from more than one area within a seed planning zone, so that seed transfer rules for that species can be observed when the seeds are used.

In summary, to estimate seed collection requirements, the following information is required for each species and provenance:

1) the area to be planted annually, within a seed planning zone and elevational range;

2) the number of trees to be planted per hectare, based on local stocking standards established by the Forest Service;

3) the number of trees potentially available from seeds in storage, plus those available from seed orchard seeds; and,

4) the average number of plantable seedlings per hectolitre of cones.

FIGURE 7. Seed planning zones

SEED PLANNING ZONES

COAST

DYM	Dry Maritime
SSM	Southern Submaritime
CSM	Central Submaritime
NSM	Northern Submaritime
WTM	Wet Maritime
NWM	Northern Wet Maritime
HPM	Hypermaritime

SOUTHERN INTERIOR

TOD	Thompson Okanagan Dry
TOA	Thompson Okanagan Arid
SA	Shuswap Adams
WK	West Kootenay
MIC	Mica
BSH	Bush
EK	East Kootenay

CENTRAL NORTHERN INTERIOR

CP	Central Plateau
BLK	Bulkley
MRB	Mt Robson
QL	Quesnel Lakes
MGR	McGregor
CT	Cariboo Transition
NCH	Nechako
CHL	Chilcotin
BB	Big Bar
FIN	Finlay
HH	Hudson Hope
FN	Ft Nelson
DK	Dease Klappean
NST	Nass Skeena Transition

FIGURE 8. The Tree Seed Register

PAGE 30
SOWING5 TREE SEED REGISTER AND INVENTORY SYSTEM - SOWING5 REPORT 1988-12-21

INVENTORY AND SEEDLING POTENTIAL

INCLUDING: ALL ACTIVE SEEDLOTS - SORTED BY: REGION, SEED ZONE, SPECIES, AGENCY, ELEVATION AND SEEDLOT.

FOREST REGION - KAMLOOPS SEED ZONE - TOA

SPP	OWN -ER	ELEV (KM)	MAP GRID (N.T.S.)	AGENCY	SEED -LOT	GEN CL	LOCATION	MONT UNIT	BGC ZONE	BGC SUB-ZONE	COLL YEAR	GERM (%)	POTENTIAL K TREES (BR)	POTENTIAL K TREES (CO)
FDI	C	.701	082 L 012	BCFS	00278	B5	MONTE CRK	KAMLOO			1958	96%	8.3	6.2
FDI	C	.762		BCFS	26284	B5	TFL 35	TFL 35			1957	92%	504.4	365.5
FDI	C	.775	092 I 013	BCFS	03406	B3	PAVILION	YALAKO			1978	95%	352.6	257.0
FDI	C	.823	082 L 005	BCFS	00902	B1	WESTWOLD	KAMLOO			1964	94%	58.8	43.3
FDI	C	.850	082 L 012	BCFS	03359	B3	PAXTON VAL.	KAMLOO			1978	71%	366.3	224.5
FDI	C	.850	092 I 012	BCFS	03407	B3	MCGILLIVARY	YALAKO			1978	92%	686.4	497.4
FDI	C	.853	082 L 005	CZINT	01374	B5	SALMON R	TFL16			1966	84%	1,101.5	614.5
FDI	C	.914	082 L 005	CZINT	01376	B5	SL 26287	TFL16			1966	90%	297.9	220.7
FDI	C	.950	082 L 005	BCFS	26287	B5	TFL 16	TFL 16			1966	90%	631.7	467.9
FDI	C	.975	092 I 027	BCFS	08273	B2	MAHIT LAKE	NICOLA	IDF	A	1988	%	.0	.0
FDI	C	1.067	092 I 002	BCFS	00148	B5	INDIAN RES	BARTON			1957	86%	74.4	55.6
FDI	C	1.158	082 L 005	CZINT	01371	B3	SALMON LK	NICOLA			1966	65%	381.0	179.9
FDI	C	1.275	092 I 013	BCFS	03363	B3	CROWN LAKE	BOTANI			1978	89%	6,467.5	4,671.6
FDI	C	1.300	092 I 003	BCFP	03538	B4	NICOAMEN R	BOTANI			1978	87%	1.5	1.1
FDI	C	1.300	092 I 016	BALCO	08360	B2	RHODA LAKE	NISKON	MSA		19	97%	7.3	5.4
FDI	C	1.300	092 P 001	MEYER	04316	B3	JAMIESON CR	TFL35			1979	77%	6.5	3.8
FDI	C	1.380	092 I 003	BCFP	08315	B2	NICOAMEN CREEK	BOTANI	IDF		1985	90%	672.3	498.0
FDI	P	1.450	092 I 013	AINSLC	08320		TIFFIN CREEK		IDF	B	1988	%	.0	.0
PLI	C	.980	082 L 012	BCFS	08140	B2	MILLER LAKE	CHUSHA	IDF		1984	98%	222.5	136.2
PLI	C	1.128	092 I 008	CZINT	04265	B3	GOODWIN CR	TFL16			1980	95%	668.0	405.7
PLI	C	1.219	082 L 005	CZINT	02255	B3	EQUISES CR	OKANAG			1973	64%	84.0	33.6
PLI	C	1.219	082 L 005	LAVING	02234	B3	PINAUS LK	OKANAG			1973	59%	21.3	8.9
PLI	C	1.225	092 I 008	BALCO	08078	B3	BEAVERHOUSE LK.	KAMLOO	IDF		1983	98%	807.2	494.2
PLI	C	1.230	082 E 013	CZINT	08353	B2	TFL 9	TFL09	IDF		1980	94%	698.4	428.6
PLI	C	1.280	092 I 013	BCFS	08312	B3	MCKAY CREEK	YALAKO	IDF		1983	95%	3.9	2.4

For: Interior spruce

Area to be planted annually
in a given seed planning zone and range described by seed transfer rules
(excluding areas for which there is a current supply of seedlings)
1 000 hectares

Stocking
1 200 trees/hectare

Annual seedling requirement
1 000 hectares X 1 200 trees/hectare
= 1 200 000 trees

Planning period
10 years
Total seedling requirement = 12 000 000 trees

Seedlings potentially available
from seeds in storage = 200 000 trees

Total Deficit
1 200 000 trees - 200 000 trees
= 11 800 000 trees

Plantable container trees per hectolitre of cones
73 000 trees/hectolitre

Volume of cones required to fill deficit
over planning period
11 800 000 trees / 73 000 trees/hectolitre
= 137 hectolitres

1 Hectolitre (hl)	= 2.75 Imperial bushels = 2.83 U.S. bushels

FIGURE 9. Sample seed need calculation

Current average seed yields and the number of plantable trees which can be expected per hectolitre of cones are provided, by species, in Table 4 and in Section 5. This information is updated regularly for seed stored at the Forest Service Seed Centre. The most recent information available should be used in all calculations. Estimates of this type are essential to determine the size of specific crops to be collected and to establish levels of funding required, should suitable crops develop (Figure 9).

Crop Forecasting

The next step in planning potential collections is to forecast the probability of successful crop development in specific collection areas. Early crop forecasting is generally accomplished through bud sampling. This involves collecting a branch from several well-distributed trees in each stand being surveyed. Trees used in bud sampling should be dominant or co-dominant in the stand, with well-developed crowns, and ideally should be between 45 and 80 years of age. Older trees, or those whose branches have been distorted from previous crops and/or collections, are not suitable. Branches should be obtained from that portion of the crown in which the collection is going to take place, for example, in the top third of trees from which cones will be collected aerially. Furthermore, branches must only be collected from the cone-bearing portion of the crown (see Section 5 of this guide for species specific information), regardless of collection technique, and should be removed as close to the main stem as possible.

By late winter/early spring of the crop year, buds may be identified by recognizable external characteristics, or by internal features, visible after the buds have been sectioned with a razor blade or scalpel. All female buds on the branch, from the tip to three internodes back, are counted and recorded for each tree. The exact quantitative relationship between female bud counts and size of the potential crop remains obscure for most species. In general, however, the larger the number of female buds in relation to vegetative buds, the greater the potential for a cone crop. The word "potential" is stressed, since the many impediments to cone and seed development may, at any stage, cause the reproductive structures to abort or may destroy the maturing seeds. In other words, bud sampling can result in a conclusion about whether a crop might develop. A collectable crop is not ensured until shortly before collection. Nevertheless, early crop forecasting can be of great value to forest managers in planning and establishing a budget and work schedule for cone collection operations.

Vegetative and reproductive buds of Sitka spruce are shown on page 13. For all species, reproductive buds usually are larger than vegetative buds. When sectioned, the tissues of reproductive buds will be seen to fill the bud cavity more than they do in vegetative buds. Female buds tend to be larger, more pointed, and broader at the base than male buds. When sectioned, or exposed by removal of the bud scales,

TABLE 4. Average seed yields

Species	No. of Seedlots	Average % Germination	Yield per HL of cones: Kg of clean seeds per hl of cones Min	Max	Wt.Avg	Number of viable seeds per hl of cones Min	Max	Wt.Avg	Average number of plantable trees (thousands) per: Kg of clean seeds Bareroot	Container	hl of cones Bareroot	Container[1]
Cedars:												
western red (Cw)	245	82	0.026	3.095	1.22	15 570	2 501 866	897 837	218	211	266	258
yellow (Cy)	2	40	0.010	3.050	0.93	1 323	325 494	93 965	34	42	32	39
Douglas-fir:												
coast (Fdc)	468	89	0.019	1.015	0.46	691	81 268	39 577	28	20	13	9
interior (Fdi)	509	89	0.008	2.629	0.81	758	191 647	70 343	25	17	20	14
Hemlocks:												
mountain (Hm)	67	74	0.067	1.623	0.85	12 972	612 927	356 428	102	112	87	95
western (Hw)	394	86	0.008	3.540	0.86	2 865	1 637 781	366 698	108	114	93	98
Larches:												
tamarack (Lt)	3		0.092	0.290	0.17	19 806	46 589	32 001	94	76	16	13
western (Lw)	44	83	0.060	1.722	0.73	2 718	351 012	119 312	46	45	34	33
Pines:												
lodgepole:												
coast (Plc)	23	91	0.130	1.289	0.50	45 829	394 365	176 660	118	70	43	25
interior (Pli)	630	91	0.035	3.403	0.25	9 916	529 405	70 546	116	84	29	21
ponderosa (Py)	34	94	1.000	3.040	1.93	11 962	47 880	31 522	6	4	12	7
western white (Pw)	87	58	0.015	0.997	0.38	158	29 314	7 587	13	10	5	4
Spruces:												
interior (Sx)	986	85	0.039	16.640	0.88	3 485	6 585 779	347 163	95	83	84	73
Sitka (Ss)	143	93	0.043	5.367	0.53	11 597	2 246 501	194 270	157	126	83	67
True firs:												
grand (Bg)	82	72	0.050	3.327	1.73	989	100 519	50 776	7	6	12	11
Pacific silver (Ba)[2]	243	70	0.091	5.628	2.01	104	84 439	30 389	3	9	7	18
subalpine (Bl)	62	56	0.132	8.517	1.56	608	467 907	40 582	11	400	17	32

[1] Based on average germination and current BCFS sowing rules

[2] Also known as amabilis fir

female buds have a distinct cone-like structure, whereas male buds have a raspberry-like appearance. Male buds often occur in clusters, while female buds are frequently single. Photographs that will assist the surveyor in the identification of buds of specific species can be found in Eis and Craigdallie (1981).

In species with long reproductive cycles, such as yellow-cedar and pines, bud surveys are unnecessary. Crop forecasting for these species can be carried out more accurately by simply counting the 1st-year cones in the fall before crop maturity.

Crop Monitoring

The decision to collect cones is based on a systematic crop monitoring process. When cones become readily visible in early summer, suitable stands in areas of identified seed needs are surveyed and the magnitude of developing crops is rated. Later, as the seeds begin to mature, the seed crop is evaluated.

Crop rating

Crop rating involves locating likely stands and assessing the relative size of developing cone crops, generally in late-June or early-July. Crop rating is a visual assessment of the relative number of cones in the cone-bearing portion of well-distributed, representative dominant and co-dominant tree crowns. Both the number of cones on each cone-bearing tree and the percentage of trees bearing cones in the stand must be assessed. Observations are rated numerically (Table 5). Separate ratings are completed for each species and each stand.

Cone crop rating is highly subjective and largely dependent on the surveyor's experience. Of particular importance is the surveyor's understanding of the cone production characteristics of the species being assessed. The number of cones produced, and their distribution through the crown, varies with tree species. For example, 80-100 cones on a white pine or true fir would probably be classed as "many", while the same number of cones on a mature spruce or Douglas-fir might

TABLE 5. Cone crop rating

Crop rating		Definition (refers to dominant and co-dominant trees only)
1	None	No cones
2	Very light	Few cones on less than 25% of the trees
3	Light	Few cones on more than 25% of the trees
4	Light	Many cones on less than 25% of the trees
5*	**Medium**	**Many cones on 25-50% of the trees**
6*	**Heavy**	**Many cones on more than 50% of the trees**
7*	**Very heavy**	**Many cones on almost all of the trees**

* Crops rated as 5 or more are generally considered collectable. Where crops rated as 4 or 5 are considered for collection, seed evaluation should be intensive to ensure adequate yields.

go unnoticed. While thousands of cones can constitute "many" on a spruce tree, the same numbers could be classed as "few" on a mature cedar. In developing judgements about "few" and "many" cones, attention should be confined only to the cone-bearing portion of the crown. In white pine and true firs, cone production is limited to the top four or five whorls, whereas in cedars and lodgepole pine, cones occur throughout the crown. In crowns bearing numerous cones, branches often appear to sag under the weight of the crop. Medium and heavy crops (Table 5) are collectable; however, in the case of severe seed shortages, crops rated as "4" may also be collected in smaller quantities to meet immediate seed needs.

The reliability of estimates also depends on the number of trees observed and how well these trees represent the entire stand. Errors in rating cone crops commonly arise when old cones are included as part of the current crop, and when evaluation is restricted to roadside trees which, because of their increased exposure to sunshine, often bear more cones than do those within the stand. Unless the crop is only to be harvested from roadside trees, both errors result in an overestimate of crop size. Visibility can be improved if surveyors ensure that the sun is behind them while viewing the crop. The use of helicopters in crop monitoring assists in surveying large and/or inaccessible stands.

Cones may be examined for evidence of insects and disease at the time of crop rating, but the main objective at this time is to assess the size of the crop and to compare potential collection areas. Each stand must have sufficient area and number of cone-bearing trees to meet collection quotas and to be cost effective.

The cone and seed crop report form (FS 727) (Figure 10) is useful for recording crop ratings, as well as results of the subsequent, more detailed, cone and seed evaluation. At the time of crop rating, only the upper part of the table is completed. The data may also be used to refine estimates of local crop periodicity.

Based on results obtained from cone crop ratings, potential collection areas are selected. These areas will continue to be reassessed throughout the maturation period to determine seed quantity, maturity, and overall condition.

Cone and seed evaluation

Cone crop rating provides estimates of cone production in one stand relative to another, whereas evaluation is an assessment of seed yield per cone, seed quality and maturity. Such evaluations are conducted in early to mid August in the same stands that were previously rated. Cone collection costs and the periodic nature of crop production make it imperative that cone crops considered for collection yield adequate amounts of high quality seeds.

Cone and seed evaluation involves a detailed examination of cone samples from cone-bearing trees which are well distributed throughout the stand. Form FS 727 (Figure 10) illustrates one means of recording sample data, for as many as nine cones per tree from six trees. It is not always possible to evaluate this number of cones, but the reliability of the seed crop estimate increases as the number of cones and trees examined increases. It is preferable to sample a few cones from many trees, rather than many cones from a few trees. Sample cones should be obtained from various aspects and levels throughout the cone-bearing portion of the crown. Cone samples may be obtained by using a helicopter, climbing the trees, shooting branches off, or collecting from recently felled trees in an active logging area.

Province of British Columbia — Ministry of Forests

CONE AND SEED CROP 19____

☐ VCL (Lot) _____ Region _____ Dist. _____ Species (one) _____
☐ Tenure _____ CP _____ Blk _____ Seed Zone _____
Licensee _____ PSYU/TSA _____ Elevation (m) _____
☐ Private (owner) _____ Nat. Topo./UTM Grid _____ Stand age _____
☐ Other _____ Location _____ Assoc. spp. _____
Biogeoclimatic Subzone _____ Forest Ecosystem Type _____

1. Numerical Cone Crop Rating (One Species)
(Rate only dominant and codminant trees of cone-bearing age)

DESCRIPTION OF CONES OBSERVED	CROP IS	CIRCLE RATING
No cones on any trees	Nil	1
Few cones on < 25% of trees	Very Light	2
Few cones on > 25% of trees	Light	3
Many cones on < 25% of trees	Light	4
Many cones on 25-50% of trees	Medium	5
Many cones on > 50% of trees	Heavy	6
Many cones on almost all trees	Very Heavy	7

Average volume of cones/tree _____ (hl) X est. number of collectible trees/ha _____
X Area of stand _____ (ha) = a potential crop of _____ hectolitres
Date _____, 19____ Rated by _____ Position _____

2. Evaluation – Number of Exposed Filled Seeds per Half-cone

Tree No.	Upper Crown 1	2	3	Middle Crown 4	5	6	Lower Crown 7	8	9	For 9 Cones Total	Aver.
1											
2											
3											
4											
5											
6											
For 6 Trees											

(Circle item below)
Cone Colour
Greenish, purplish, pale/dark brown
Seed and Wing Colour
White, pale/dark brown
Endosperm
Clear, milky, white
Embryo
Clear, white, yellow
..... % of cavity

Insects/Disease present ☐ No ☐ Yes Evidence _____
_____ % Cones/Seed infected _____
Recommend for collection ☐ No ☐ Yes To start about _____
Suggested method of collection _____
Access _____
Comments _____
Evaluation by _____ Position _____ Date _____

F.S. 727 SIL 85/2 ORIGINAL REG. MAN. - SILV. 2nd CANARY - REG. MAN. - SIL. 3rd PINK - ORIGINATOR

FIGURE 10. Cone and seed crop report form (FS 727)

Cones may be examined in the field or carefully labelled and brought back to the office. With the exception of the cedars and lodgepole pine, cones are sliced in half longitudinally along the cone axis with a sharp knife or cone cutting tool (Figure 11). The cut cones should be examined to ensure that the axis has been bisected; if it has not, the cone must be discarded and another sliced. The number of exposed, filled seeds in one half-section is counted and recorded; the other half-section of each cone is discarded. For seed evaluation purposes, "filled" means only those seeds containing storage tissue ("endosperm"); it is not necessary to determine the presence of embryos during this count. Only those seeds that have been sliced open sufficiently so that the presence of storage tissue is readily verifiable are counted as filled. Seeds that were not sliced open (i.e., the seedcoat remains intact) are ignored. For yellow-cedar, western redcedar and lodgepole pine cones, a different procedure is recommended. Since these cones are difficult to section longitudinally, they should be cut transversely at one-half the cone's length from the base, and the filled seeds on one cut face should be counted (Figure 12). A 10X hand lens should be used during evaluation, particularly for small-seeded species such as cedars, hemlocks, lodgepole pine, and spruce. The filled seed count per cut face may then be used to calculate the number of filled seeds per cone according to the equations provided in Table 6.

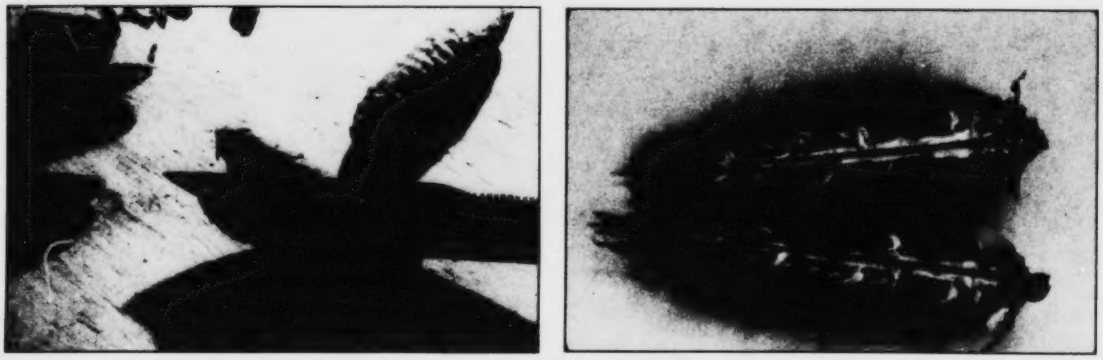


FIGURE 11. Longitudinal sectioning of an interior spruce cone and a sectioned Douglas-fir cone

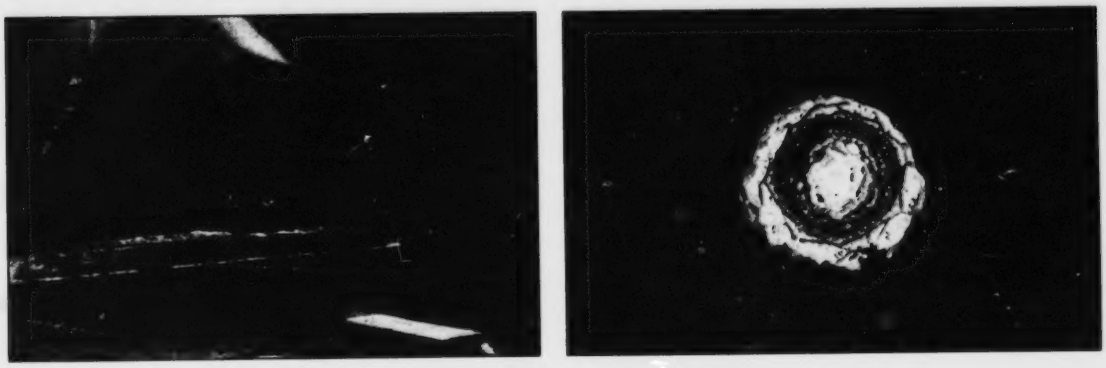


FIGURE 12. Transverse sectioning of a lodgepole pine cone

Species	Filled seeds per whole cone (WC) (S = Filled seed count per half cone)	
Longitudinal Section		
Douglas-fir		
coast	WC = 4.3S + 3.2	$r^2 = 0.71$*
interior	WC = 2.3S + 2.5	$r^2 = 0.71$
Spruces		
Engelmann	WC = 6.3S + 6.0	$r^2 = 0.89$
Sitka	WC = 10.1S + 8.7	$r^2 = 0.76$
white	WC = 6.3S + 4.0	$r^2 = 0.73$
True firs		
subalpine	WC = 8.3S + 11.1	$r^2 = 0.77$
grand	WC = 5.0S + 17.9	$r^2 = 0.77$
Pacific silver	WC = 9.4S + 27.5	$r^2 = 0.67$
Transverse Section		
Lodgepole pine	WC = 3.0S + 7.6	$r^2 = 0.48$
Western white pine	WC = 6.2S + 24.5	$r^2 = 0.41$
Western hemlock	WC = 2.8S + 3.5	$r^2 = 0.60$
Western larch	WC = 6.0S + 7.9	$r^2 = -0.59$
Cedars		
western red		
coast	WC = 1.4S + 0.8	$r^2 = 0.83$
interior	WC = 1.2S + 1.1	$r^2 = 0.77$
yellow	WC = 0.5S + 4.3	$r^2 = 0.65$

* This is the correlation coefficient, which is a measure of the strength of the relationship between S (the observed value) and WC (the predicted value). The closer r^2 is to 1.00, the stronger the relationship.

TABLE 6. Equations for estimating the total number of filled seeds per cone

Species	Recommended minimum filled seeds per: Exposed face of half cone	Whole cone
Cedars:		
western red (Cw)	2*	4-6
yellow (Cy)	2*	4
Douglas-fir (Fd)	5	-
Pines:		
lodgepole (Pl)	5*	20
ponderosa (Py)	7	75
western white (Pw)	-	90
Spruces:	7	-
True firs:		
grand (Bg)	12-14	-
Pacific silver (Ba)	8-12	-
subalpine (Bl)	4-6	-
Western hemlock (Hw)	3	-

* Cut transversely at half cone length from the base.

TABLE 7. Minimum average filled seed counts recommended for cone collections

An alternative, more tedious method for evaluating a lodgepole pine crop involves extracting and cutting individual seeds to determine whether they are filled. Lodgepole pine seeds can be extracted by first dipping the cones in boiling water for about 1 minute, or until the sound of cracking resin bonds stops, and then drying the cones in a 60°C oven for about 8 hours. Alternatively, the cone may be dried in a microwave oven at full power for a few minutes. Once the scales in the top third to half of the cone have reflexed, the seeds can be shaken out for examination. Care should be taken not to "overcook" the cones, since this will damage the seeds and make assessment difficult.

The average of the half or whole-cone seed counts indicates the potential seed yield and, when compared to the minimum standard (Table 7), determines whether or not the crop is collectable. Again, the cone and seed crop report form (FS 727) (Figure 10) is designed to assist in the compilation of this information.

For all species, intact seeds should be extracted by hand from a sample of cones so that seedcoat and seedwing colour, as well as moisture content, can be assessed through the seed cutting test. The presence and extent of insect and disease damage are also more easily identified by breaking up the half-section. In general, if more than 50% of the seeds are damaged, collection is not considered worthwhile. The presence of insects in cones is often signalled by external features such as premature browning and/or flexing of the cone scales, small bore holes on the cone scales, accumulations of frass, pitch, or disfigurement of the cone. Internal evidence of insect damage may include bore holes, frass, damaged seeds, or insect larvae. Spruce cones should also be checked for the presence of rust. Cones infected by this disease usually open prematurely, causing seed development to cease.

In most cases, the final selection of collection areas is determined by the seed crop evaluation. Consequently, it is important to assess the degree of seed maturity as well as the extent of the crop. The technique most commonly used to assess seed maturity is the seed cutting test.

The seed cutting test

This test, along with other indices of maturity, is used to determine when cones should be harvested, as well as to monitor seed quality during collection and interim storage. This test should not be confused with the procedure just described for evaluating filled seed content and general crop condition.

In the seed cutting test, 10-20 seeds taken at random from those extracted by

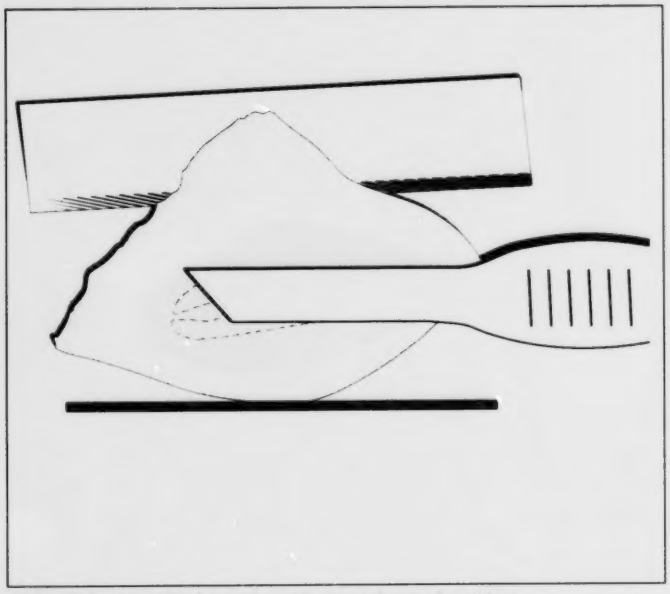


FIGURE 13a. Preferred methods of seed cutting

FIGURE 13b.

hand from the sampled cones are sliced into equal parts with a razor blade or scalpel. Unless the seed has been properly bisected, true embryo elongation cannot be observed. The preferred method of slicing a seed is to stand it on its narrower edge on a cutting surface, using forceps to hold it in place. A vertical cut is then made downward through the seed between the prongs of the forceps (Figure 13a). Another method is to place the seed flat on a firm surface, and to slice it parallel to the cutting surface (that is, horizontally) (Figure 13b). Both methods result in the seed being cut in the same way (Figure 13c). A third, but less desirable method is to make a vertical cut, but with the seed lying flat on the surface (Figure 14a). This is easier to do, especially under field conditions, but since the seed is cut through its narrowest dimension (Figure 14b) the development of the storage tissue is less accurately assessed. (If this method is used, the storage tissue is best evaluated when the cut face of a sliced cone is examined). This third method is particularly useful for small seeds such as spruce, lodgepole pine, western redcedar and yellow-cedar. The contents of all seeds, both large and small, are more accurately appraised if a 10X hand lens is used to examine them.

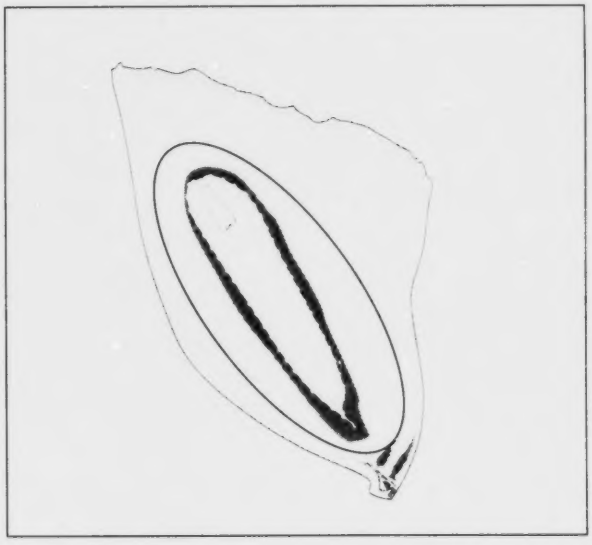


FIGURE 13c.

As coniferous seeds mature, embryos elongate and change colour from white to pale yellow. The surrounding storage tissue changes from a viscous milky condition to a firm consistency (similar to the meat of a coconut). The seedcoat and seedwing darken in colour and are easily lifted from the cone scale. It should be noted that when seeds are viewed under magnification, the tissues appear to be more moist than they really are.

Seed cutting tests need not begin until early August. Before this time, unfertilized ovules may appear to be developing normally and, when sectioned, such seeds

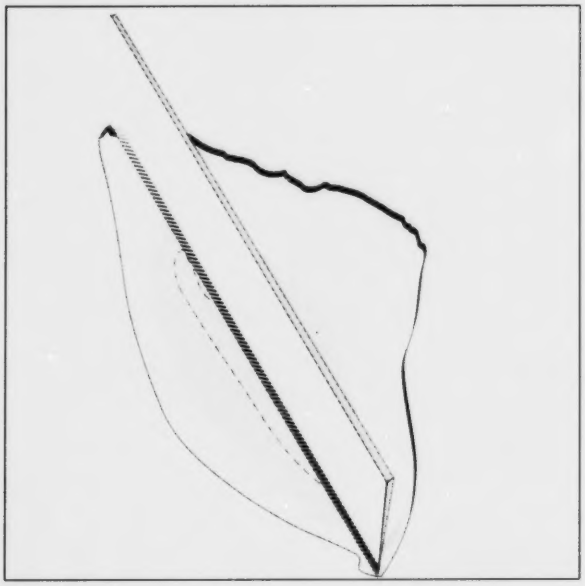


FIGURE 14a. An alternative method of cutting a seed

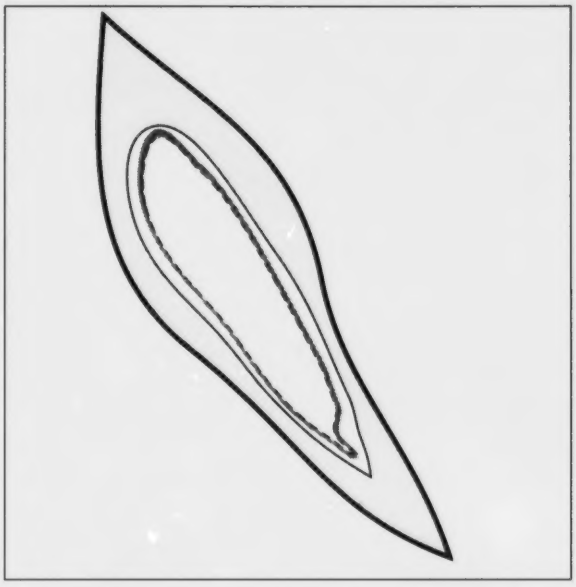


FIGURE 14b.

FIGURE 15. Seed with missing embyro

FIGURE 16. An aborted seed

will contain storage tissue and will appear to be filled. The embryo, however, will be missing (Figure 15). Between late-June and mid-July, most unfertilized ovules cease development and their contents shrivel (Figure 16). Therefore, delaying the seed cutting test until after this period avoids the danger of seed yield estimates being inflated because unfertilized seeds were counted. The seed cutting test may need to be repeated several times to determine the earliest date of collection.

Seeds are considered sufficiently mature (Figure 17) for collection when several criteria have been satisfied. The most important of these is that the embryos must fill at least 90% of the cavity within the storage tissue. (This cavity is formed in the storage tissue irrespective of the presence of an embryo). Also, cut seeds that have been exposed for several hours (even overnight) must show no evidence of storage-tissue shrinkage. This is particularly important, because the embryo and storage tissue do not mature simultaneously. Most often, the storage tissue matures after the embryo has completely elongated. Maturation of the storage tissue is important to maximize seed storability and germinative vigour. Considerable shrivelling and shrinkage away from the seedcoat indicate that the seed's moisture content is still too high and that collection should be delayed (Figure 18). There is evidence that if suitable storage conditions can be provided, when embryos have reached 75% elongation within the storage tissue the seeds will continue ripening even after the cones have been removed from the parent tree. However, such artificial ripening (sometimes known as "after-ripening") is not reliable. It is advisable at all times to allow cones to ripen, and embryos to reach at least 90% elongation, before collections begin.

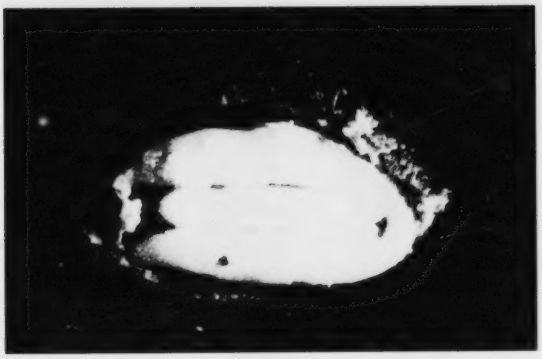


FIGURE 17. A healthy, mature Douglas-fir seed

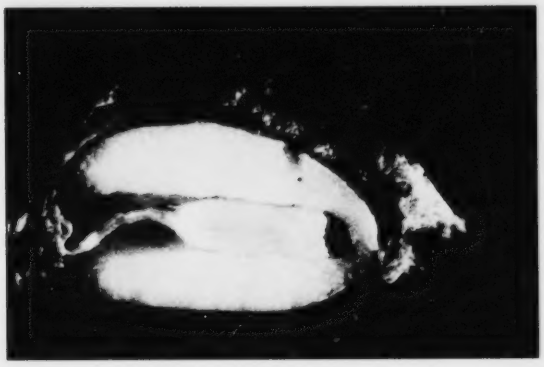


FIGURE 18. A healthy immature seed

Pre-Collection Organization

Whereas *collection planning* is decision-oriented and concerns whether, where, and when to collect, *pre-collection organization* is action-oriented, and involves activities such as preparing collection areas, accumulating and readying equipment, arranging for pickers and transportation, and setting up interim cone storage facilities. When two or more areas are scheduled for collection, priorities must be assigned according to seed needs, anticipated maturation date, species, elevation, location, and available labour.

The first step in organizing any cone collection is to determine the most efficient and cost effective method of collecting the crop. Options available in British Columbia are collection by helicopter, climbing the trees, or felling the trees. Collections from squirrel caches are generally discouraged, but may be appropriate under certain circumstances. The choice of collection method will depend on species, location, and funding. Cone collection techniques are described in Section 4.

Once the collection method has been decided, some specific issues must be addressed. For example, if the choice is felling, related matters such as utilization of timber, sale arrangements, permits, and other logging details must be considered. Another major concern is proximity to landings, roads, or skid trails. As well, the area into which the crowns fall should be relatively clear of brush or slash to facilitate access and cone gathering. Trees to be felled or climbed for cone collection should be marked. In selecting trees, safety and other practical factors must also be considered. Thus, if collection is to be accomplished by climbing, only trees that permit safe climbing and efficient cone gathering should be selected. If the choice is aerial collection, sufficient space for safe landing and fueling must be available or constructed. Landing and picking areas must be positioned so that there is no hazard to the pickers, and an adequate supply of fuel must be available at the site. Regardless of the collection technique, roads and skid trails should be improved and windfalls removed to facilitate access.

Crop size, crop density, anticipated picker productivity, and collection quotas all influence labour requirements, including the number of pickers and the supervision required. Picker productivity depends on many factors, such as the size of the cones being collected, the effort required to detach cones from the branch, the numbers of collectable cones (those that have matured in the collection year and are free of visible insect or disease damage) on each branch, the weather, and picker motivation.

Average collection productivity information for individual species is provided in Section 5. These values are based on productivities reported to the B.C. Forest Service for post-1978 collections of medium to good crops. Generally, pickers are paid by the hectolitre; however, in certain instances, such as where new collection techniques are being tested, special prices or hourly rates may be more appropriate.

It may be necessary to place advertisements in local newspapers before hiring pickers. In some localities, groups such as Junior Forest Wardens, Boy Scouts, and sporting clubs, may be interested in collecting cones. All interested individuals or groups should be provided with information about the probable starting date and expected collection duration, the species to be collected, equipment the picker must provide (e.g., clothing, gloves, boots, lunch), whether Workers' Compensation Board (WCB) coverage is required or provided, rate of pay (per hectolitre), and method of payment. A phone list of interested pickers should be kept to facilitate immediate contact when the crop is ready for harvest. When cones are harvested by helicopter (see Section 4), coordination of operations among agencies collecting in the same area will maximize the aircraft hours available for cone picking.

Transportation must also be organized in advance of actual collections. This includes vehicles for pickers, as well as for transporting cones to the interim storage facility. All vehicles and boats should be inspected and serviced in advance, as well as checked for proper licensing, insurance, and safety features. The supervisor should also ensure that assigned operators are qualified and have an appropriate Driver's Licence to operate crew vehicles and/or large transport trucks.

As with transport, all necessary equipment should be organized and in good working order before the start of any collection. Cone sacks, tags and ties, spray paint, collection report forms, hand cleaner and a first aid kit will be required for all collections. A general equipment checklist is provided in Appendix 3.

Cone collection operations have been assigned a class "B" hazard rating by the WCB, and the pertinent regulations apply. It is essential that supervisors be familiar with the appropriate WCB regulations (1980) and that the required first aid equipment is provided in all vehicles and is on-site at all times. In addition, a certified first aid attendant should be present at each collection.

Hazards such as snags, unsafe trees, and wasps nests must be eliminated from the picking area. Equipment, including vehicles, boats, aircraft, chainsaws, rakes, clippers, and personal safety equipment associated with climbing and clipping must be checked to ensure that it is of the proper type and in good condition. Equipment operators must be qualified, capable and, when necessary, properly certified. The WCB requires that hard hats be worn by workers on the ground and recommends that they also be worn by tree climbers. Clothing requirements may vary according to the collection technique. Collection areas should be located well away from active logging and, since cone collection generally occurs during the hunting season, collection areas should be clearly marked, roads signed, and picking crews issued with brightly coloured safety vests.

When pitchy cones are collected, disposable plastic surgical gloves are useful. Pickers should be instructed to avoid rubbing their eyes when their hands are pitchy, since this may result in eye irritation. Commercial hand cleaners work most effectively to remove pitch from pickers' hands and gloves, and should be provided at all collections along with paper towelling or clean rags.

The collection supervisor must also ensure that interim cone storage facilities are available within a reasonable distance of the collection site. Facilities may already exist at Forest District or company Divisional compounds, or it may be necessary to build temporary shelves or racks which are large enough to hold the anticipated collection in a way that allows air movement between the sacks. All interim storage facilities must have a roof and good ventilation, and be situated in a cool, shaded location. Portable fans help to promote air movement. In addition, it may be necessary to protect cones in interim storage against predation by squirrels, chipmunks, or mice, as well as against theft.

The quality and quantity of seeds collected, and the efficiency of the collection operation, will depend not only on the degree of pre-collection organization, but also on the knowledge and competence of the collection supervisor. Therefore, these persons should be well trained and experienced in all facets of the collection operation, from collection standards to safety and record keeping. Periodic training or annual updating sessions may be required. Pickers should be briefed at the beginning of each collection. At this time, the supervisor should review working conditions, standards, and safety matters. Detailed instructions must be given on proper use of equipment, identification of trees from which cones are to be harvested, cone acceptability standards, and the proper method of filling, tying, and tagging cone sacks.

If pre-organization has proceeded as it should, an efficient, well-organized collection operation can be expected. When checks show the cone crop to be ready for picking, the cone pickers, equipment, and interim storage facilities must also be ready. It only remains to collect the crop.

Seed Production Stands

Seed production stands may be reserved in anticipation of calculated seed shortfalls for specific species and provenances. It is also good practice to reserve superior stands of locally important species at appropriate elevations in seed planning zones where substantial reforestation is expected over the next 20 years. Procedures for reserving seed production stands are described in the B.C. Forest Service Silviculture Manual (1987). Cone production in immature reserved stands can be encouraged through intensive silvicultural treatments such as thinning and fertilization. Protection against fire, insects and disease should also be intensified in reserved stands, and any undesirable parent trees should be removed. The location and extent of seed production stands and areas must be noted in government and company atlases to ensure that timber harvesting is excluded and that crop monitoring is continued.

Stands reserved for the purpose of seed production should:

- be of cone-bearing age;
- occur on productive sites with a history of frequent cone crops;
- contain a high proportion of desirable trees (trees of good form and free from disease or insects);
- be at least 300 m from stands containing a high proportion of undesirable trees, to avoid pollination by such trees;
- be accessible at reasonable cost; and
- be large enough to meet anticipated cone collection quotas.

Several alternative sites should be selected in case primary collection areas are lost through fire, insects, disease, adverse environmental conditions, or loss of access. Desirable trees, that is, good phenotypes, are healthy, fast-growing dominants or co-dominants, with straight stems free from defects such as fluting, forking, epicormic shoots, and spiral grain. Branch bases should be small in diameter in relation to the stem, and the branches should project from the stem horizontally, or angle slightly upward. The tree crown should be healthy and compact for the species, yet have abundant foliage. Trees with deformed stems or branches, or those showing evidence of mistletoe or other diseases — even though such trees may contain the heaviest crops — are not suitable for cone collection. Also, isolated trees (i.e., more than 100 m from the nearest stand of the same species) should be avoided, as cones on such trees are often inadequately pollinated. Undesirable trees should be marked so that they can be easily identified and excluded from collection. Selection of good phenotypes during planning improves the chances of obtaining high quality seedlings. though this is not guaranteed, because the pollen parents remain unknown.

Seed Orchards

To ensure a regular supply of genetically improved seeds, 44 cooperative seed orchards, covering 123 hectares, have been established to date in British Columbia. Of the total orchard area, 26% is occupied by coastal Douglas-fir, 36% by interior spruce, 14% each by western hemlock and lodgepole pine. The cedars, Pacific silver fir and Sitka spruce occupy the remaining 10% of the total orchard area. It is expected that by the late 1990's, these and new orchards will provide genetically-improved seeds for roughly one-half of British Columbia's annual planting program.

Seed orchards are usually situated in areas where the environment favours frequent cone production. Reproductive bud initiation and cone crops are favoured by fertile, well-drained soils, a dry warm climate, and a long growing season with small likelihood of late spring frosts.

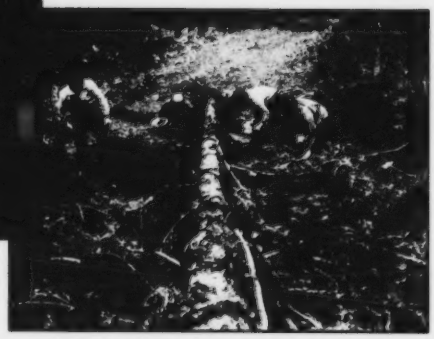
Management of seed orchards provides orchardists with the opportunity to apply treatments that stimulate flower production, favour cone development, and prevent or control losses from insects or disease. Parental crosses can be manipulated, and contamination from undesirable pollen sources can be minimized. Flower development, pollination, cone ripening, and timing of cone collections can be controlled.

Sources of Collection Planning Information

Topic	Sources
Artificial ripening ("after ripening")	Edwards 1980
Cone and seed evaluation	B.C. Min. For. and Lands 1987b; G. Miller, pers. comm., 1988, Forestry Canada (formerly the Canadian Forestry Service), Pacific Forestry Centre, Victoria, B.C.
Crop forecasting	B.C. Min. For. and Lands 1987b; Eis 1973b; Eis and Craigdallie1983
Crop monitoring	B.C. Min. For. and Lands 1987b
Pre-collection organization	Workers' Comp. Board 1980
Seed cutting test	B.C. Min. For. and Lands 1987b; H. Rooke, pers. comm., 1988, B.C. Min. For. Seed Centre, Surrey, B.C.
Seed orchards	B.C. Min. For. 1985a; Zobel and Talbert 1984
Seed production stands	B.C. Min. For. and Lands 1987b
Seed transfer rules	B.C. Min. For. and Lands 1987a

4 CONE COLLECTION AND HANDLING

Aerial raking



Collecting cones by climbing

Collecting cones from felled trees

Cleaning cones in the field

Proper labelling of cone sacks

Makeshift field cone shelter

4 Cone Collection and Handling

Methods

The choice of method to be used in specific cone collection projects depends on both the crop and the techniques available. Factors to consider include:

- species
- crop size
- quantity of cones to be collected
- site characteristics
- the capabilities of each harvesting technique
- safety
- efficiency
- cost

As stated previously, aerial, climbing, and felling are the cone collection methods used in British Columbia. The advantages and disadvantages of these techniques are summarized in Table 8. Occasionally, cones are collected from squirrel caches.

Aerial

Aerial cone collections involve the use of a helicopter and either a manually-operated shearing device or an unmanned cone rake. These techniques are referred to as clipping and raking, respectively, and are the only aerial techniques approved by the Federal Ministry of Transport.

In clipping operations, the helicopter hovers near the tree top while the clipper operator cuts off either the cone-bearing top or branches with an hydraulic pruner or electric chainsaw. The branches and/or tops of several trees are stowed in the rear cabin of the helicopter and are subsequently unloaded at the dump site, where the cones are removed. This technique requires some aircraft modification before cone collection.

Raking involves the use of an unmanned, cone-shaped device surrounded by a wire basket. The rake is topped with a cutting head fitted with sharpened, upward-oriented edges. The rake, which is suspended from the helicopter, is lowered 4-6m over the tree top until most of the cone-bearing branches protrude through the upper opening of the rake. As the rake is raised by the helicopter, branches are stripped from the main stem, and fall into the basket. The branches collected during one flying cycle, usually from 5 to 10 trees, are then carried to the dump site, where they are unloaded for cone harvest. Branches can also be deposited directly into dump trucks and hauled to a more convenient covered worksite, such as a warehouse.

All safety requirements associated with aerial collection techniques must be strictly observed. The helicopter company must be certified for aerial cone collections and the pilots must be appropriately qualified. Aerial collection operations

TABLE 8. Advantages and disadvantages of common cone collection techniques

Collection Technique	Species most often collected	Advantages	Disadvantages
Aerial General	B, Fd, Hm, S	• good where cones are concentrated on top whorls of conical, narrow crowns • rapid, efficient • good for remote areas • facilitates collection at peak of maturity • doesn't require felling of trees • allows collection from reserved stands such as streamside buffers or game corridors • allows for selection of vigorous phenotypes • allows pickers to work in a central and/or sheltered area	• requires heavy crop and high seed counts to be cost effective • collection area should be within 3 km of dump site to be cost effective • only cones near tops of trees can be collected • dangerous in the presence of snags taller than live canopy • may be hampered by inclement weather • in general cannot work if: windspeed is more than 32 kph; ceiling is less than 150 m; horizontal visibility is less than 0.8 km; and/or if vision is impaired due to rain
Raking	B, Fd, S	• good where canopy uniform • as aerial - general	• present estimates indicate only 50% of cones available are recovered • as aerial - general
Clipping	S, Immature Fd	• good where tops are well-spaced and above main canopy • permits collection of highest quality cones based on operator's judgement • as aerial - general	• dangerous if terrain too steep or there is a high incidence of snags • cannot operate at windspeeds greater than 16 kph or gusty • size of top harvestable limited to 2.4 m in length • becomes inefficient if more than two passes per tree are required • demands highly qualified pilots and precise flying • shear operator must have successfully completed training course • pilot and operator must be compatible • as aerial - general
Climbing	Fd, Lw, Pw, Py	• efficient where crop on scattered trees • minimizes damage to trees • allows selection of specific trees from which to collect • good for small collections or where cones must be removed with minimal damage to trees	• trees must be open grown and full crowned with large, well-spaced branches • often difficult to find climbers
Felling	Fd,Cw, Hw, Lw, Pl, S, Cy	• inexpensive when carried out in conjunction with logging • maximizes cone retrieval from species in which cones are throughout crown • good for species with serotinous cones, since this enables pickers to wait until falling completed	• requires removal of trees from which cones are to be collected • cone collection and logging must be coordinated • large percentage of cones may be knocked from falling trees and lost in debris • higher potential for debris • higher potential safety hazard for pickers

are subject to WCB Amended Accident Prevention Regulation 33.00 (Appendix 4). Flight safety is the responsibility of the pilot, whose instructions on air operations and procedures must be followed. Collections must be suspended the moment safety is in question. Safety at the dump site is the responsibility of the collection supervisor. During aerial collections, all loose objects at the fueling and drop sites must be secured. If possible, separate dump sites should be arranged so that pickers can work well away from the helicopter's rotor wash, noise, and dust. Ground personnel must remain clear of all aircraft, and only those persons designated by the collection supervisor should attend to the harvesting device. In clipping operations, only certified clipper operators can be employed.

Emergency procedures must be well understood by all personnel before the start of operations. All helicopter and designated ground personnel are to be equipped and qualified to take appropriate emergency action in the event of an accident. First aid is to be administered immediately to injured personnel, on site, until transport to the nearest hospital can be provided. In the event of a downed aircraft, all personnel will remain at the crash site until rescue is complete. All injuries are to be reported to the collection supervisor immediately. Aircraft will be considered overdue if no communication has been received for 30 minutes, at which time the nearest Air Traffic Control Centre, the helicopter company's office, and the appropriate B.C. Forest Service and/or forest company office are to be notified. Detailed discussions of safety in aerial collections are described in the sources cited at the end of this section.

The efficiency and cost of aerial cone harvesting will depend on:

- the size of the crop being collected
- the frequency of cone-bearing trees
- cone size
- seed yields (filled seed counts)
- the efficiency of the equipment being used
- the size and manoeuverability of the helicopter
- turn-around time
- ground organization
- the experience and ability of the pilot(s)

Aerial collections should be co-ordinated among agencies to minimize ferry times to and from the dump site(s), and to consolidate mutual collection quotas.

Climbing

The collection of cones by climbing may be practical in young, open-grown stands of species such as ponderosa pine, white pine, Douglas-fir, and occasionally larch. Trees selected for climbing should be full crowned and less than 15 m tall. Branches should be well spaced, begin near ground level, and large enough to safely support the picker. The majority of cones on trees to be climbed should be within the picker's reach, while the picker remains belted to the main stem.

Safety precautions must be rigorously maintained during any climbing collection. Safety belts and straps must be checked at least twice each day. Except for

brief periods when the picker is moving from one level to another, the safety belt must be attached around the main stem of the tree. Tools such as pruning poles and cone rakes should not be carried while the tree is being climbed. They should be hoisted up later by a light haul line, and returned to the ground in a similar manner.

The climber should begin picking at the top of the tree and work down and around the crown. Cones may be placed in sacks, or dropped to the ground and sacked later. Dropping cones is not suitable for all species, (e.g., true fir cones usually shatter on impact), and it is best done only when there is ground vegetation to soften the impact. Cones should not be collected from the lower branches of the tree, since cones on these branches are often self-pollinated. Pickers should also ensure that the area beneath the tree in which they are working is clear before dropping cones or lowering equipment or filled sacks. Readers contemplating climbing collections should consult the references cited at the end of this chapter.

Felling

Cones may be collected from trees felled either especially for collection purposes or as part of a logging or clearing operation. Cones should only be collected from trees of good phenotype and, ideally, only these trees should be felled before cones are collected. The remaining trees can be removed later, if it is appropriate to do so. Felling must be delayed until seeds are sufficiently mature, after which cones should be collected as soon as possible, generally within 1 to 4 days of felling. When trees are felled too far in advance of picking, some cones may be taken away by squirrels. Other cones exposed to the sun often show signs of overheating and desiccation, and may become casehardened. During seed extraction, such cones tend to remain partially unopened, even after prolonged kilning.

Trees should be felled in a manner that facilitates the maximum recovery of cones. This involves good directional falling so that crowns are placed on or across unused roads, landings, or other areas cleared of brush. To ensure crew safety, pickers must remain at least three tree lengths from the site of felling.

Where collections are made on active cutting permits, agreement must be obtained in advance from the licensee. It is important that trees are felled in accordance with cutting permit specifications and by competent fallers approved by the logging foreman. Fallers must be briefed on any specific requirements for the cone collecting operation.

Squirrel caches

Cones may be collected from squirrel caches when quotas cannot be met through other collection methods, provided that the source stand is of good quality. Collections from squirrel caches are otherwise discouraged since parent-tree phenotype is uncertain and cached cones may be infected with the disease *Caloscypha fulgens* (seed fungus, or cold fungus). When attacked by this disease, seeds appear to be normal, but may be mummified and incapable of germinating. This disease has been found in stored seeds of Douglas-fir, grand fir, interior spruces and Sitka spruce (Appendix 2).

Squirrels usually put their caches in the same places year after year. Typically,

these are in damp areas, on northern exposures, and in decayed wood or duff, or around old dead and downed hollow logs or windfallen trees. Fresh cones on the ground in August are a sign of squirrel activity and may indicate a nearby cache but are not necessarily a sign that cones are mature. If cones are collected from squirrel caches, total depletion of the cache should be avoided to ensure that a sufficient supply of winter food remains.

Collection Quality

To ensure that seed quality is maintained throughout all stages of seed handling, the crop should be monitored regularly during collection and while it is in temporary storage. Monitoring is the responsibility of the collection supervisor. Filled-seed content, embryo and storage tissue condition, insects or disease damage, and cone condition should be assessed and recorded during each day's collection. These assessments are useful when completing the cone collector's report form, and they ensure that continued collection is worthwhile. In aerial collections, cones from each load should be monitored to guide the pilot to the best portions of the stand and, because of the large area covered, to ensure that seed quality is comparable throughout the collection area. The collection supervisor must ensure that cones are collected only from trees exhibiting good phenotypic characteristics, and that cones and seeds meet all maturity standards.

All collections should meet established quality standards. Because of the periodicity of cone crops, there is no guarantee that additional collections of the same species and provenance will be possible within the planning period. Consequently, care must be taken to minimize reductions in seed quality and seed yields as a result of immaturity and/or damage during collection and post-harvest handling.

Cones of most species may open and reclose several times before seedfall, depending on climatic conditions. In some species, such as spruce, almost complete reflexing of the cone scales is required before seeds begin to be shed; consequently, there is no need to collect until cones first show some scale reflexing. Readers are cautioned, however, that some species, such as western redcedar and white pine, shed their seeds quickly after minimal reflexing of the cone scales (see Section 5 for species-specific information). Also, not all the cones on a single tree, or within a stand, mature at exactly the same time. Thus, provided losses of seeds due to initial natural shedding are minimized, it is better to delay collections to ensure maturation in the bulk of the crop, than to begin too early.

In addition to ensuring that seeds are mature and of good quality, it is also the collection supervisor's responsibility to ensure that post-collection handling procedures do not result in the deterioration of seed quality. Recommended standards for collections of British Columbia conifers are summarized in Table 9.

Cone Handling

Cones must be carefully handled after they are removed from the tree. Seeds are very perishable and can be irrepairably damaged if cones are not properly handled after harvest, even if the cones are collected at the peak of maturity. **Damage incurred in the field cannot be remedied during extraction and processing.**

Cones should be picked from the branches, cleaned, and sacked as quickly as

TABLE 9. Recommended cone and seed collection standards

Crop characteristic	Standard
CONE CROP RATING	• 5 or more
FILLED SEED CONTENT	• minimum average number acceptable as defined in Table 7
MATURITY	
Embryo	• present and filling at least 90% of the embryonic cavity • creamy yellow to pale green • cotyledons visible with 10x hand lens
Storage tissue	• white • not translucent • nut-like in texture • little or no shrinkage after drying
Seedwing	• tan to golden brown • brittle after drying • easily detached from cone scale
Cones	• slight flexing of scale margins • golden to medium brown • *Abies* may be purplish or greenish grey
CLEANLINESS	• less than 5% debris and unacceptable cones in collections of all species except Sw, Hw and Cy • less than 10% debris in collections of Sw, Hw, and Cy • less than 25% class III and IV of Pl cones
SACKS	• must be made of a material woven in a manner which allows good air circulation and moisture exchange • clean, dry and undamaged • must contain no more than 0.4 hl of cones • must be securely tied near top • must display seedlot number clearly and have attached a completed shipping tag with duplicate copy inside
STORAGE	• sacked cones must be shaded, dry and well-ventilated • sacks must be racked lying flat • temperatures inside cone sacks should not exceed 25°C • should provide protection against vandalism and predation
SHIPPING	• sacks of cones must be protected, kept well-ventilated and dry • pallets must separate layers of cone sacks • reefer temperature must be maintained at 5-10°C during transport • processing facility must be informed and prepared to accept shipments • all shipments must be accompanied by the collection reports and a list of seedlots • should involve the least time possible

possible. Cones should be free of debris such as needles, twigs, bark, litter, stones, and dirt. Unacceptable cones (those that show signs of heavy insect or disease damage, are unusually small, or have opened prematurely) should be removed.

Debris causes damage by the abrasion and bruising of seed tissue during extraction, and results in decreased seed viability. Debris and unacceptable cones also add moisture to the collection, promoting development of mould and inhibiting drying. Unacceptable material should be removed at the collection site or, if this is not possible, at the temporary storage facility. Clean collections will reduce the risk of seed damage during storage and in transit to the processing facility, as well as improve extraction efficiency. Extra care should be taken if seeds are being released from the cones at the time of collection. Released seeds are no longer protected by the cone and are much more susceptible to damage.

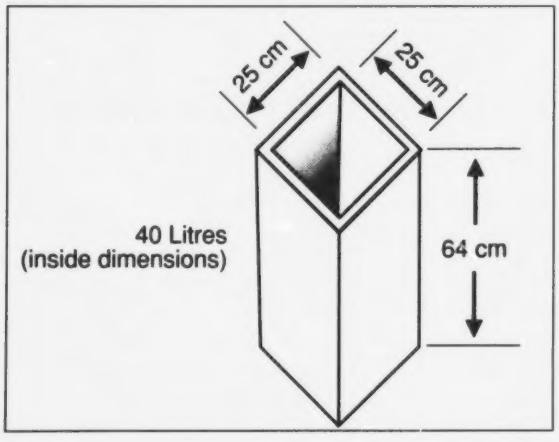
Mould is encouraged by overheating, which results from wet, improperly sacked, and poorly ventilated collections. Heat is naturally produced as cones dry and expand, but excessive heat can result in direct damage to the seeds. Moisture, overheating, and mould problems are particularly prevalent in immature collections. Collections of cedars, hemlocks, and true firs, which have characteristically high cone and seed moisture contents at maturity, are especially prone to such damage.

FIGURE 19. A properly filled cone sack

When cones are moist at the time of collection, they should be spread out and air-dried for several days at the temporary storage facility, then re-sacked in clean, dry sacks. Sacks should be made of a material such as burlap, which is durable and allows good air and moisture exchange. Tightly woven fabric and solid or woven plastic bags inhibit circulation and promote mould and overheating. (For specifications when purchasing cone sacks, contact the Forest Service Seed Centre.)

When filled to the "fill-line," cone sacks used in British Columbia will contain 40 litres (0.4 hl) of cones (Figure 19). Half-filling sacks may be appropriate when collections are made during inclement weather, and for collections of cedars, hemlock, true firs, and, in some cases, spruce. When cone sacks are not filled completely, a cone volume measure (Figure 20) should be used to correctly tally the volume collected by each picker. This measured volume is the basis of payment, and will be used to settle any payment disputes arising over cone volumes contained in "filled" sacks. Payment is always based on the volume of clean cones.

FIGURE 20. Cone volume measure



Sacks should be securely tied well above the fill-line, allowing ample room for expansion and good air circulation. Cone sacks should never be overfilled, since cones expand as they dry. If this expansion is restricted, the cone scales may set in a partially opened position, a condition that impairs seed extraction. Similar guidelines must be observed when re-sacking cones dried at the temporary storage facility.

At the collection site and during temporary storage, sacks of cones should be stored on racks that are shaded and protected from the rain. Each sack should be surrounded by air space and turned regularly, at least once a week, to further reduce the risk of overheating and mould. Temperatures exceeding 25° C inside the sacks will cause damage to the seeds. In addition, collections may need to be protected

from squirrels and rodents.

The seedlot number must be spray-painted on each cone sack and recorded on the shipping tag. Shipping tags should be durable (i.e., weatherproof and tearproof). Each tag should have two copies. One is placed inside the sack to identify the cones in case the tag secured to the outside of the sack is lost. The tags indicate the collection agency, species, collection location, and number of sacks in the same seedlot (Figure 21).

Sacks should not be loaded into vehicles until shortly before transport. Filled cone sacks should be transported daily from the field to a central temporary storage facility. Cones must be kept dry, cool and well ventilated during transport, and at regional storage facilities. Cone sacks should be separated on pallets during transport and sacks should be kept away from the walls of the truck, to allow for adequate air circulation. Similar conditions must prevail during transport to the processing facility.

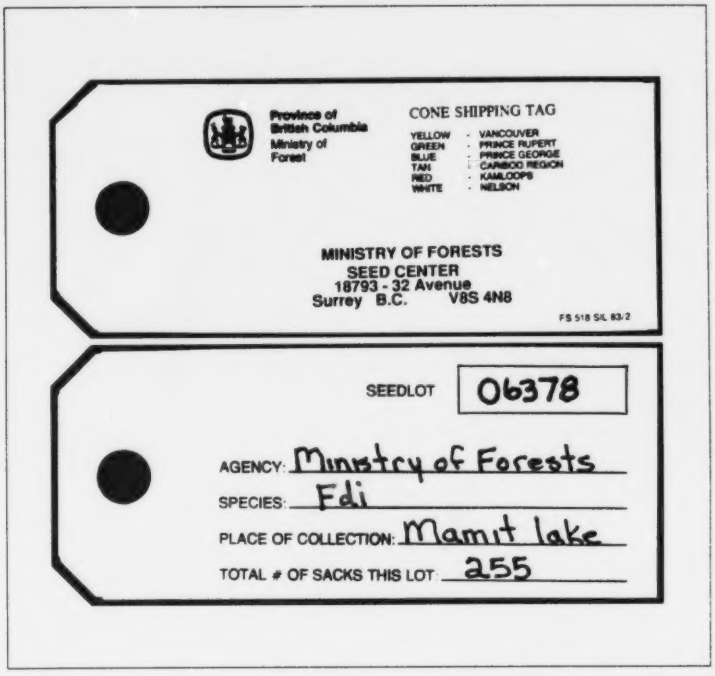


FIGURE 21. Sample cone shipping tag

In general, cones should not be transported to the processing facility until requested by the plant manager. Good communication is required between the collection agency and the processing facility to ensure prompt transfer of cones on arrival at the plant. Travel time to the processing facility should be as short as possible, and refrigerated trucks kept at 5°-10° C should be used. For most species, cones should be kept in interim storage for at least 4 weeks, or until air-dried. Species such as western hemlock and western redcedar, however, require prompt transport to the processing facility. Seeds of these species sometimes germinate while still in the cones, particularly if cone temperatures rise to about 15°C (which can occur when these species are harvested in mild conditions, combined with the natural heat generated as the cones dry and expand). The risk of such premature germination can be reduced by providing cool, well-ventilated conditions during temporary cone storage and transport, and by prompt extraction of the seeds.

Each collection must be accompanied by a completed cone collector's report (FS 721) (Figure 22). It is the collection supervisor's responsibility to ensure that the appropriate documentation for the collection is completed, and that all cone sacks are properly marked with the seedlot number and tagged before cones leave the collection area. Completion of the cone collector's report form is essential for seedlot registration.

Accurately completing both the collection report and shipping tags, as well as painting the seedlot number on each cone sack, is necessary to ensure that all sacks in one seedlot can be identified before extraction. Accurate identification is particularly important because processing facilities may receive collections from many sites simultaneously. Unidentified cones will not be processed. The cone collector's report form also provides information for the provincial Tree Seed Register, which tabulates seed availability and suitability, by seedlot, for subsequent reforestation use. The seedlot number is the means by which seed testing results are organized. All seedlots sent to the Forest Service Seed Centre, for which an invoice for services is to be levied, must be accompanied by a cone-seed services form (FS 722) (Figure 23).

FIGURE 22. The cone collector's report form (FS 721)

Province of British Columbia — Ministry of Forests

CONE COLLECTOR'S REPORT

(From natural stands and/or plantations)

REGISTRATION NUMBER	CROWN SEED ✓ / PRIVATE SEED
06378	

SPECIES COLLECTED	SEED CLASS
Fdi	B2

ELEVATION (METRES)
1050-900

SEED ZONE	REGION	DISTRICT
2040 TOA	K	06

UTM GRID COORDINATES									
ZONE	EAST					NORTH			
1	0	6	5	8	0	5	5	6	9

NATIONAL TOPOGRAPHIC GRID
92I02

LATITUDE	LONGITUDE
50° 15'	120° 46'

LOCATION OF COLLECTION: Mamit L.

TSA: Merritt PSYU: Nicola

BIOGEOCLIMATIC ZONE (AND SUBZONE): IDFa

VCL LOT: 2248, 3640, 4430

LICENCEE:

PRIVATE OWNER:

AGENCY COLLECTED FOR: Ministry of Forests, SBFEP

ADDRESS: 2196 Quilchena Ave., Bag 4400, Merritt, B.C. V0K 2B0

COLLECTED BY: D.K. Heli-Cropper International Ltd.

COLLECTION SUPERVISOR: J. Smith

COLLECTED FOR: ☑ GENERAL STOCK ☐ RESEARCH ☐ OWNER'S USE ☐ SPECIAL REQUEST

COLLECTION STARTED: 88/9/07 FINISHED 88/9/12 19 88 NO. OF DAYS COLLECTING 5

AGE OF TREE COLLECTED FROM ☐ < 40 ☑ 40 - 100 ☐ > 100 YRS.

OTHER SPECIES IN STAND: Py

ASPECT: SW ☐ BOTTOMLAND ☑ BENCH ☑ SLOPE ☐ RIDGE ☐ VARIABLE

COLLECTION METHOD: ☐ CLIMBING ☐ FELLING ☐ RAKING ☐ OTHER (GROUND) ☑ HELICOPTER RAKING ☐ HELICOPTER CLIPPING ☐ HELICOPTER TOPPING

NO. TREES COLLECTED FROM: 100+ VOLUME OF CONES COLLECTED: 63.75 HECTOLITRES

NO. OF PICKER DAYS: 50 CONDITION OF CONES WHEN PICKED: clean, healthy

ENDOSPERM CONDITION: ☐ CLEAR ☐ MILKY ☑ WHITE ☑ FIRM ☐ OTHER

EMBRYO CONDITION: ☐ WHITE ☐ PALE YELLOW ☑ YELLOW 100 % OF EMBRYO CAVITY FILLED

CONE CROP RATING: AVERAGE SEED COUNT / HALF CONE: 5.6 OR NO. FILLED SEEDS/CONE:

CONES CLEANED BY: ☑ HAND ☐ SHAKING TABLE ☐ ROLLER ☐ OTHER ☐ NOT CLEANED

CONDITION OF CONES WHEN SHIPPED: clean, dry, pitchy CONDITION OF CONTAINERS: dry

SHIPPED BY: ☑ OPEN TRUCK / TRAILER ☐ VENTILATED VAN ☐ OTHER

SHIPPED TO INTERM STORAGE AT: Merritt District Warehouse DATE: Sep.9,10,11,12 19 88

INTERM STORAGE: ☑ OUTSIDE COVERED ☐ VENTILATED ROOM ☐ OTHER

SHIPPED 255 CONTAINERS TO EXTRACTORY AT: Surrey Seed Centre DATE: Sept. 28 19 88

SUPERVISOR'S COMMENTS: Cones were showing some fine white mould at time of shipping to Seed Centre, due to wet weather in the week prior to shipment. Sacks turned on a weekly basis during interim storage and sacked at 0.25 hl. per sack.

DISTRICT COMMENTS:

SECTION 88 NUMBER:

SIGNED: J. Smith POSITION: District Silviculturist DATE: Sept. 27 19 88

PART 1 – IMMEDIATELY UPON COMPLETION OF FORM MAIL THIS COPY TO:
MINISTRY OF FORESTS SEED CENTRE, BOX 816, DUNCAN, B.C. V9L 3Y2

F.S. 721

FIGURE 23. A sample cone-seed services form (FS 722)

Province of British Columbia — Ministry of Forests

CONE-SEED SERVICES

C 1629

CLIENT - NAME AND ADDRESS: BCMF (SBFEP)
2196 Quilchena Avenue
Bag 4400, Merritt, B.C. V0K 2S0

DATE Sept. 27, 1988
PHONE NO.: 378-9309
P.O. NUMBER: ---------

PLEASE PROVIDE THE SERVICES INDICATED TO THE SEEDLOTS LISTED HEREUNDER:

SEEDLOT NUMBER	SPECIES	CONES		SEEDS		CONES/SEEDS NOW LOCATED AT
		NO. OF SACKS	ESTIMATED HECTOLITRES	NO. OF PKGS.	ESTIMATED KILOGRAMS	
6378	Interior Douglas-fir	255	63.75			

SERVICES REQUESTED (described on reverse) (CHECK) — NOTE: DO NOT WRITE IN SHADED AREA - TO BE COMPLETED AT SEED CENTRE. — FEE ($)

☑ EXTRACTION AND PROCESSING
- TRUE FIRS (ABIES) _____ HL @ $ _____
- LODGEPOLE PINE _____ HL @ $ _____
- OTHER SPECIES _____ HL @ $ _____

PLUS: BASIC CHARGE OF $ _____ PER SEEDLOT X _____ SEEDLOTS =

☑ TESTING: @ $ _____ PER SEEDLOT X _____ SEEDLOTS = _____

☑ SEED STORAGE: _____ kg @ _____ PER YEAR = _____

☐ OTHER TREATMENT OR SERVICE: _____

TOTAL FEE FOR SERVICES: $ _____

FORM OF PAYMENT:

☑ INVOICE TO CLIENT MINISTRY ACCOUNT # 04891

☐ INVOICE TO CLIENT AT ABOVE ADDRESS

I HAVE READ, UNDERSTAND AND AGREE TO THE DESCRIPTIONS AND CONDITIONS OF SERVICE, AND THE LIMITATIONS OF THE MINISTRY'S LIABILITY AS STATED ON THE REVERSE OF THIS REQUISITION, AND I HEREBY AUTHORIZE THE PERFORMANCE OF THE SERVICES REQUESTED.

J. Smith
(Signature)

J. Smith
(Type or Print Name)

District Silviculturist
(Position)

	Y	M	D	INITIALS
SERVICES COMPLETED				
RECORDS UPDATED				
FORWARDED TO F.S.B.				

COPY 1 (WHITE) Seed Centre - Invoice COPY 2 (CANARY) Seed Centre - Records COPY 3 (PINK) Client

FS 722 SIL 88/07

Tests are performed on all seedlots arriving at the provincial processing facility to access maturity, insect and disease damage, and debris content, before the cones are processed. After extraction and processing, further testing takes place to determine seed yield, purity, moisture content, seed weight, and germination. Testing results are recorded in processing reports (Figure 24) which are sent to all collectors. The results of seed tests and other data are used to determine sowing requirements and to estimate future seed needs, as well as to inform potential users of seedlot quality.

The attention given to collection quality, beginning with the selection of collection sites through to post-harvest handling, influences and the quality of seeds available in storage and the costs of obtaining them. Processing and testing results provide an excellent means of reviewing field procedures and improving the quality of future collections.

Sources of Cone Collection Information

Topic	Sources
Aerial	B.C. Min. For. and Lands 1985; 1987b; Fandrich 1986; Hedin 1984; Wallinger 1986; Workers' Comp. Board 1980
Climbing	B.C. Min. For. and Lands 1987b; Yeatman and Nieman 1978
Felling	B.C. Min. For. and Lands 1987b
Seed registration	B.C. Min. For. 1988

TREE SEED PROCESSING & TESTING RESULT SUMMARIES (1987-88) REGION: _____ AGENCY: _____

REGISTRATION #	#SACKS	#Hl	SPECIES	TOTAL WEIGHT (Kg)	YIELD/Hl (Kg/Hl)	GERMINATION (%)	DATE CONES Collected	DATE CONES Received at Extractory	DATE CONES Processed
8102	101	40.0	Pli	12.285	0.307	95.50	Nov 2-24	Dec 11	March 3
REMARKS: Collection received in good condition: the occurrence of debris, Class III and IV cones, insect damage/losses rated as nil to light. The weighted (by hectolitres collected) average yield per hectolitre and germination for the 1988 Interior Lodgepole pine crop have been calculated at 0.299 Kg/Hl and 95%.									
8103	128	51.2	Pli	14.615	0.285	97.50	Jan 26-March 3	March 26	May 5
REMARKS: Collection received in good condition: the occurrence of debris, Class III and IV cones, insect damage/losses rated as light. Weighted crop averages indicated in the remarks for seedlot 8102.									
8268	158	63.0	Pli	20.620	0.327	96.75	Feb 13-20	Feb 22	March 15
REMARKS: Remarks for seedlot 8102 generally apply. The only problem experienced was most tags showed seedlot 8286. Cone and seed quality reflected in the yield and germination results.									
8269	162	64.8	Pli	20.720	0.320	93.75	Feb 25-Mar 11	March 18	April 19
REMARKS: Remarks for seedlot 8268 apply.									
25581	38	15.6	Pli	4.790	0.307	97.75	Feb 1-6	March 18	April 18
REMARKS: Collection received in good condition: the occurrence of debris, Class III and IV cones, insect damage/losses rated as nil to light. The weighted (by hectolitres collected) average yield per hectolitre and germination for the 1988 Interior Lodgepole pine crop have been calculated at 0.299 Kg/Hl and 95%.									
26153	94	37.9	Pli	9.350	0.247	83.00	Feb 5-28	March 18	April 28
REMARKS: Collection received in satisfactory condition: the occurrence of debris and insect damage/losses rated as nil to light; greater volume, although still acceptable of Class III and IV cones in this collection compared to other 1988 seedlots; and grey external mold noted on cones.									

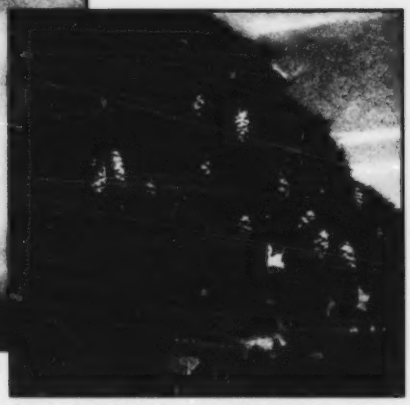
September 1988 page 1 of 1

FIGURE 24. A sample processing and testing results summary

5 SPECIFIC SEED PRODUCTION AND COLLECTION CHARACTERISTICS OF BRITISH COLUMBIA CONIFERS

Completing the cone collector's report

Light interior spruce crop



Maturing interior spruce cones

Heavy interior spruce crop

The coneworm in Douglas-fir cones

The spiral spruce cone borer in an interior spruce cone

5 Specific Seed Production and Collection Characteristics of British Columbia Conifers

The organization of any cone collection program depends on many interrelated factors, including the reproductive characteristics of individual species, the environmental and biological conditions that affect crop development and maturation, and the demand for seeds from species bearing crops. The success of the collection program, in terms of seed yield, cost effectiveness, and – most importantly – seed quality, depends on proper monitoring, harvest timing, collection, and handling.

This section contains seed production and cone collection information for 18 major coniferous species found in British Columbia. Species are presented alphabetically by scientific name. The range maps are those of Krajina *et al.* 1982. The other information has been abstracted from many sources, as cited below. Readers are encouraged to refer to the original sources for detailed descriptions of these cone and seed production characteristics. Descriptions of pests affecting cone and seed production are provided in Appendix 2. This section is intended as a guide and should be used in conjunction with local experience. The information provided should be updated as new findings become available. "Notes" sections have been provided for readers' use. Seed tranfer rules are not included in this guide since they are under review. B.C. Forest Service staff should be consulted for the latest seed transfer information.

Sources of Information for British Columbia Conifers

Topic	Sources
Collection notes	Ont. Min. Natural Resources. 1983; H. Rooke, pers. comm., 1988, B.C. Min. For. Seed Centre, Surrey, B.C.
Collection productivity	H. Rooke, pers. comm., 1988, B.C. Min. For. Seed Centre, Surrey, B.C.
Collection standards	B.C. Min. For. and Lands 1987b; Dorena Tree Improvement Centre, pers. comm., 1988, United States For. Serv., Cottage Grove, Oreg.; Eis and Craigdallie 1983; Ont. Min. Natural Resources 1983; Owens 1975; Schopmeyer 1974; H. Rooke, pers. comm., 1988, B.C. Min. For. Seed Centre, Surrey, B.C.
Cone bearing age	Eis and Craigdallie 1983; Schopmeyer 1974
Cone length	Eis and Craigdallie 1983; Hedin 1983
Cones/hectolitre	Eis and Craigdallie 1983
Ease of detachment	Apt *et al.* 1979; Hedin 1983
Periodicity	Eis and Craigdallie 1983; Ont. Min. Natural Resources 1983; Schopmeyer 1974
Pests affecting cone and seed production	Hedlin 1974; Hedlin et al. 1980; Sutherland *et al.* 1987
Plantable trees/hectolitre of cones	C. Bartram, pers. comm., 1988, B.C. Min. For., Victoria, B.C.
Position of cones in crown	Eis and Craigdallie 1983; Hedin 1983; Hosie 1979
Recommended collection techniques	Edwards 1986; Wallinger 1986
Reproductive cycle	Eis and Craigdallie 1983; Owens and Blake 1985
Species description and nomenclature	Krajina *et al.* 1982
Viable seeds/hectolitre of cones	C. Bartram, pers. comm., 1988, B.C. Min. For., Victoria, B.C.

Abies amabilis (Dougl. ex Loud.) Forbes - Pacific Silver Fir (Ba)

Ba grows in the moist coastal region of British Columbia, in the CWH and MH biogeoclimatic zones, from sea level to 1500 m, on Vancouver Island and at somewhat lower elevations on the mainland. This species has low frost resistance and requires heavy accumulations of snow to protect its roots. It is narrow-crowned and highly shade-tolerant. Ba has a very large water requirement and is generally found on moist sites.

Cone and Seed Production Characteristics

Reproductive cycle	2 years
Cone length (cm)	9-13
Cone bearing age (collectable quantities)	20 years
Cones/hectolitre	700
Periodicity	2-3 years
Viable seeds/hectolitre of cones	30 389
Position of cones in crown	Top 1/4
Ease of cone detachment	Difficult
Plantable trees/hectolitre of cones	
Bareroot	7 000
Container	18 000

Recommended Collection Standards

Filled seeds/half-cone	8-12
Cone colour	Greenish with a yellow tinge and turning grey or purplish in colour
Storage tissue	Opaque and firm
Seedcoat	Creamy or tan
Embryo	Should occupy 90% of the cavity; yellowish; radicle end may be pale green; with 10X lens, cotyledons appear well developed
Seedwing	Light brown or purplish with brown margins
Cleanliness	Less than 5% debris and unacceptable cones

Pests Affecting Cone and Seed Production

Insects

Alpine-fir seed chalcid (*Megastigmus lasiocarpae*)
Fir cone maggot (*Earomyia abietum*)

Collection Productivity

Collection technique	Hectolitres collected/man-day Average (range)
Aerial	5 (1.7 - 10.5)
Felling	1.4 (0.5 - 3.3)

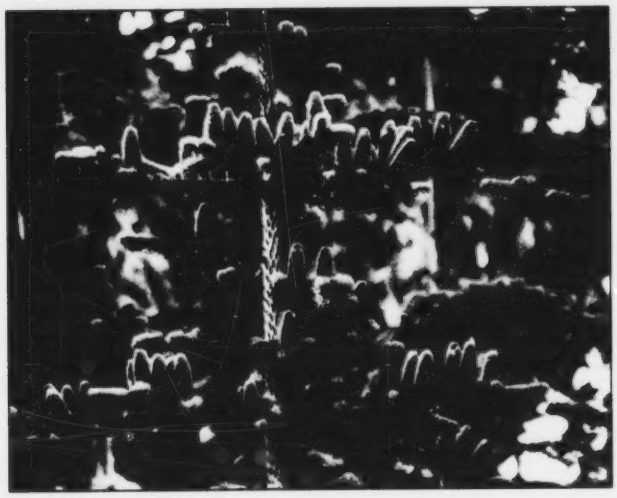
Collection Notes

1) Under the provisions of the British Columbia Plant Protection Act, Balsam Woolly Aphid Regulation (Appendix 4), the movement of *Abies* twigs is restricted. Consequently, all *Abies* cones must be completely removed from twig or branch material before they leave the collection area.

2) Ba cones disintegrate quickly following maturation and must be collected somewhat prematurely. These moist cones must be loosely sacked (20-25 litres/sack), and be kept cool, dry, and well ventilated during collection, transport, and in storage.

3) Filled seed counts should include only embryos that are more than 50% exposed.

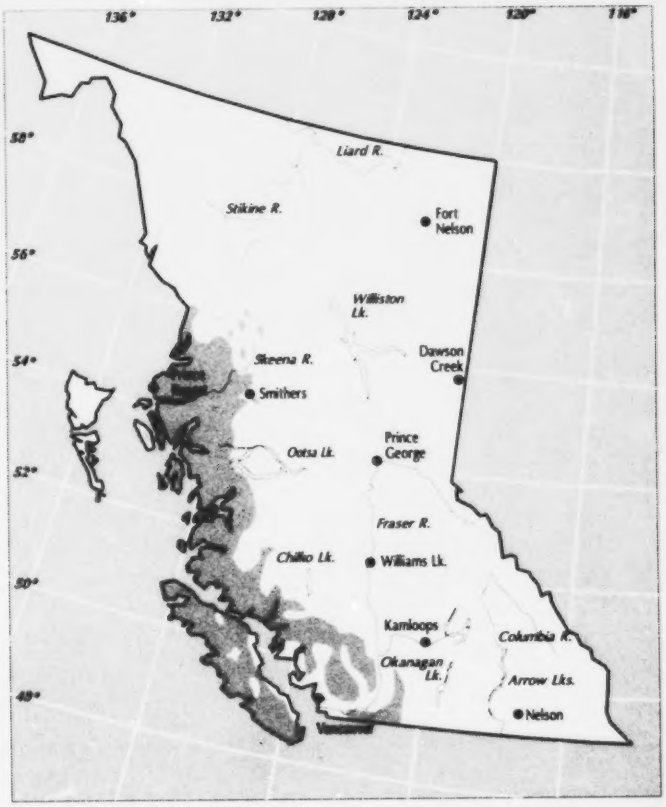
4) Insect attack tends to be high in all *Abies* species.



Many Cones

Mature Cone

Notes:



Range

Abies grandis (Dougl. ex Don) Lindl. - Grand Fir (Bg)

The range of Bg is not extensive in British Columbia This species is found on the southern coast and in the southern portion of the Kootenays. It grows in the IDF, IWH (drier subzones), and CDF biogeoclimatic zones, from sea level to 450 m at the coast and 1360 m in the Interior. This species is found on a wide variety of sites and soils. Bg prefers drier growing conditions than Ba and requires a long growing season. It also has high nutritional requirements. Bg is known to have low frost resistance on the coast. Trees growing in the Interior probably have a greater degree of resistance.

Cone and Seed Production Characteristics

Reproductive cycle	2 years
Cone length (cm)	5-12
Cone bearing age (collectable quantities)	50 years
Cones/hectolitre	700
Periodicity	2-3 years
Viable seeds/hectolitre of cones	50 776
Position of cones in crown	Top 1/4
Ease of cone detachment	Difficult
Plantable trees/hectolitre of cones	
Bareroot	12 000
Container	1 000

Recommended Collection Standards

Filled seeds/half-cone	12-14
Cone colour	Greenish with a yellow tinge and turning grey or purplish in colour
Storage tissue	Opaque and firm
Seedcoat	Creamy or tan
Seedwing	Light brown or purplish with brown margins
Embryo	Should occupy 90% of the cavity; yellowish; radicle end may be pale green; with 10X lens, cotyledons appear well developed
Cleanliness	Less than 5% debris and unacceptable cones

Pests Affecting Cone and Seed Production

Insects

- Cone scale midge (*Resseliella spp.*)
- Fir cone maggot (*Earomyia abietum*)
- Fir cone moth (*Barbara spp.*)
- Fir seed midge (*Dasineura abiesemia*)

Diseases

- Seed fungus or cold fungus (*Caloscypha fulgens*)

Collection Productivity

Collection technique	Hectolitres collected/man-day Average (range)
Aerial	3.2 (1 - 12.8)
Felling	2 (0.4 -3)

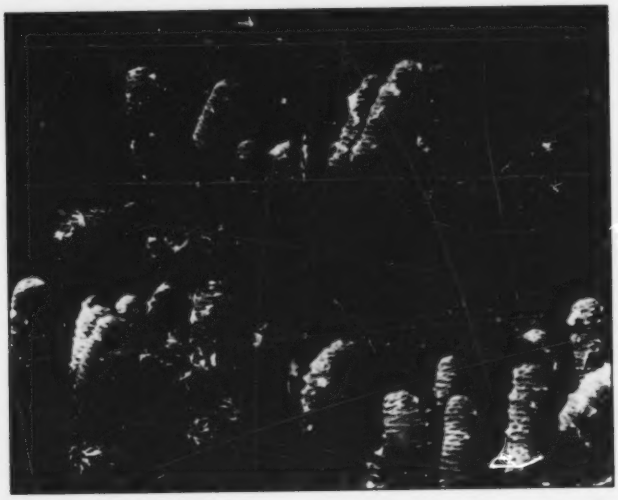
Collection Notes

1) Under the provisions of the British Columbia Plant Protection Act, Balsam Woolly Aphid Regulation (Appendix 4), the movement of *Abies* twigs is restricted. Consequently, all *Abies* cones must be completely removed from twig or branch material before they leave the collection area.

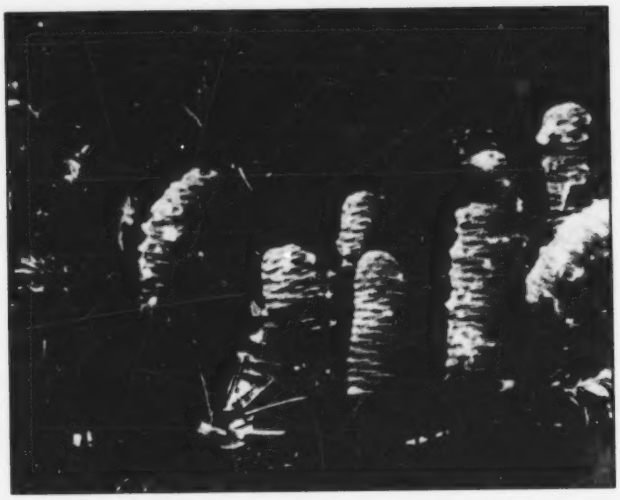
2) As in other *Abies* species, Bg cones disintegrate quickly following maturation, so they must be collected somewhat prematurely. These moist cones must be loosely sacked (20-25 litres/sack), and be kept cool, dry, and well ventilated during collection, transport, and in storage.

3) Filled seed counts should include embryos that are more than 50% exposed.

4) Insect attack tends to be high in all *Abies* species.

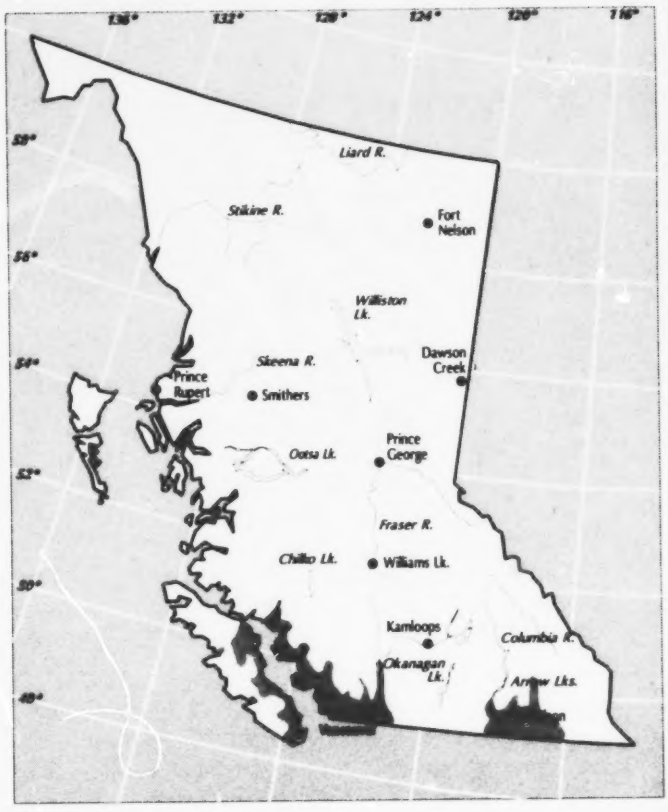


Many Cones



Mature Cones

Notes:



Range

Abies lasiocarpa (Hook.) Nutt. - Subalpine Fir (Bl)

Bl can be found in subalpine environments through much of British Columbia, at elevations ranging from 600 to 2100 m. It occurs on a wide variety of soils and sites in the ESSF, SWS and SBS biogeoclimatic zones. This species is very resistant to frost and flooding, and is shade-tolerant, although less so than Ba. It prefers humid climates with short growing seasons.

Cone and Seed Production Characteristics

Reproductive cycle ..... 2 years
Cone length (cm) 6-12
Cone bearing age (collectable quantities) ..... 20 years
Cones/hectolitre 850
Periodicity ..... 2-4 years
Viable seeds/hectolitre of cones 40 582
Position of cones in crown ..... Top 1/4
Ease of cone detachment ..... Difficult
Plantable trees/hectolitre of cones
Bareroot 17 000
Container 32 000

Recommended Collection Standards

Filled seeds/half-cone 4-6
Cone colour ..... Greenish with a yellow tinge and turning grey or purplish in colour
Storage tissue ..... Opaque and firm
Seedcoat ..... Creamy or tan
Seedwing ..... Light brown or purplish with brown margins
Embryo ..... Should occupy 90% of the cavity; yellowish; radicle end may be pale green; with 10X lens, cotyledons appear well developed
Cleanliness ..... Less than 5% debris and unacceptable cones

Pests Affecting Cone and Seed Production

Insects

Alpine-fir seed chalcid (*Megastigmus lasiocarpae*)
Fir cone maggot (*Earomyia aquilonia*)

Collection Productivity

Collection technique	Hectolitres collected/man-day Average (range)
Aerial	1 (0.9 - 1.2)
Felling	1.6 (0.2 - 4.3)

Collection Notes

1) Under the provisions of the British Columbia Plant Protection Act, Balsam Woolly Aphid Regulation (Appendix 4), the movement of *Abies* twigs is restricted. Consequently, all *Abies* cones must be completely removed from twig or branch material before they leave the collection area

2) Bl cones disintegrate quickly following maturation so they must be collected somewhat prematurely. These moist cones must be loosely sacked (20 litres/sack), and kept cool, dry, and well ventilated during collection, transport, and in storage.

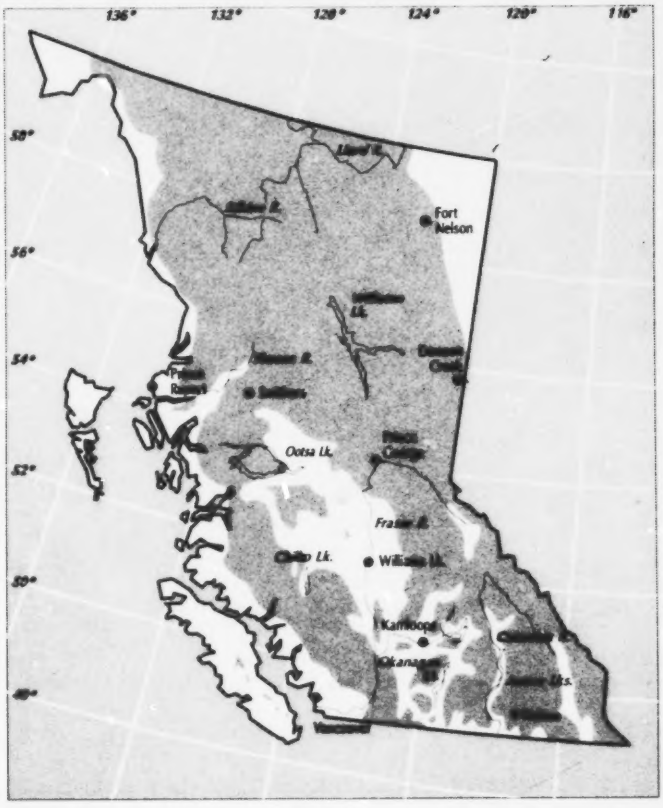
3) Filled seed counts should include only embryos that are more than 50% exposed.

4) Insect attack tends to be high in all *Abies* species.

Many Cones

Mature Cones

Notes:



Range

Chamaecyparis nootkatensis (D.Donn) Spach. - Yellow-Cedar (Cy)

Cy is found in the MH and CWH biogeoclimatic zones of coastal British Columbia. In southern British Columbia, this species is seldom found below 600 m. However, north of Vancouver Island and where it occurs in the West Kootenays, Cy can be found at all elevations below timberline. It prefers wetter sites and is shade tolerant, but it has low frost resistance unless the soil is heavily covered with snow.

Cone and Seed Production Characteristics

Reproductive cycle ..... 3 years
Cone length (cm) ..... 0.5 - 1.5
Cone bearing age (collectable quantities) ..... Unknown
Cones/hectolitre 130 000
Periodicity ..... 4 or more years
Viable seeds/hectolitre of cones 93 965
Position of cones in crown ..... Throughout
Ease of cone detachment ..... Easy
Plantable trees/hectolitre of cones
  Bareroot 32 000
  Container 39 000

Recommended Collection Standards

Filled seeds/half-cone* 2
Cone colour ..... Yellow to reddish brown
Storage tissue ..... Opaque and firm
Seedcoat ..... Dark brown and hard
Embryo ..... Should occupy 90% of the cavity; yellowish
Seedwing ..... Light brown
Cleanliness ..... Less than 10% debris and unacceptable cones

*Cut transversely at 1/2 cone length.

Pests Affecting Cone and Seed Production

Cy has no major cone and seed pests.

Collection Productivity

Collection technique	Hectolitres collected/man-day Average (range)
Felling	0.1 (0.04 - 0.4)

Collection Notes

1) Both immature (1st year), and mature (2nd year) cones can be found on the same tree and/or branch. However, seeds from immature cones will not germinate. Consequently, care must be taken to identify mature cones properly before collection. Immature cones are green, purple or a combination of these two colours. Immature seeds are white or very light green and soft.

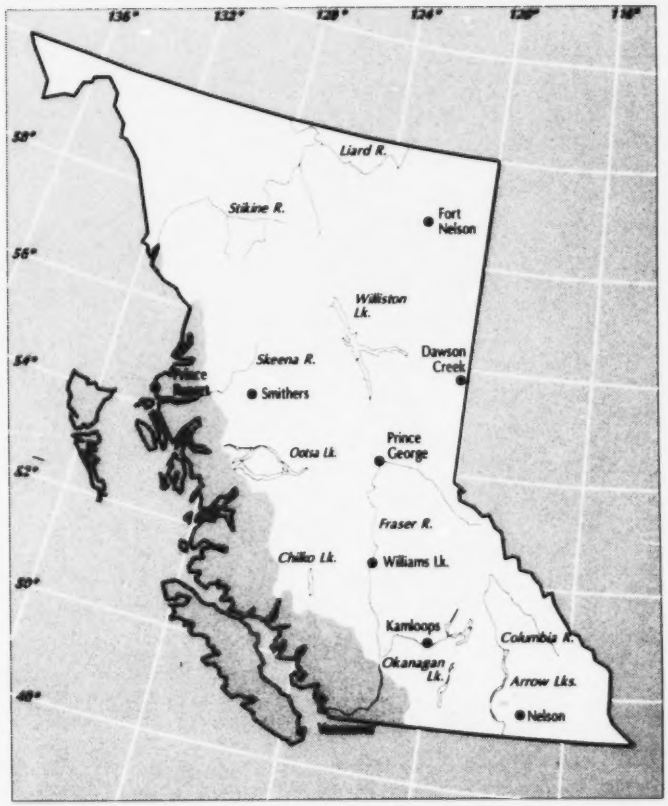
2) Mature, 2nd-year cones are hard and not easily opened with fingernails. The margins of cone scales frequently turn brown and become raised in the 2nd year. These features are often hard to distinguish. Mature cones are formed on the previous year's shoots, that is, farther in from the branch ends, than 1st year cones. The most reliable external indicator of maturity is seed colour, which changes from a creamy yellow colour in the 1st year to brown in the 2nd. However, the embryo must be examined for an accurate assessment of maturity.

3) Hand rakes help to remove cones from branches.

First-year cones

Second-year cones

Notes:



Range

Larix laricina (Du Roi) K. Koch - Tamarack (Lt)

Three *Larix* species occur in British Columbia; *Larix laricina* (Du Roi) K. Koch (tamarack); *Larix lyallii* Parl. (subalpine larch); and *Larix occidentalis* Nutt. (western larch). Of these, only Lw is presently used for reforestation. Lt is found in northeastern British Columbia, in the BWBS and SBS biogeoclimatic zones, at elevations between 180 and 520 m. This species is highly frost and flood resistant but has low shade tolerance. It has high nutritional requirements and grows best on moist, nutrient-rich sites.

Cone and Seed Production Characteristics

Reproductive cycle	2 years
Cone length (cm)	1.5
Cone bearing age (collectable quantities)	40 years
Cones/hectolitre	25 000
Periodicity	3-6 years
Viable seeds/hectolitre of cones	32 000
Position of cones in crown	Throughout non-shaded portion of crown
Ease of cone detachment	Moderate
Plantable treess/hectolitre of cones	
Bareroot	16 000
Container	13 000

Recommended Collection Standards

Filled seeds/half-cone	Unavailable (26 per whole cone)
Cone colour	Brown
Storage tissue	Opaque and firm
Seedcoat	Golden to reddish-brown
Embryo	Should occupy 90% of the cavity; white to yellow
Seedwing	Tan
Cleanliness	Less than 5% debris and unacceptable cones

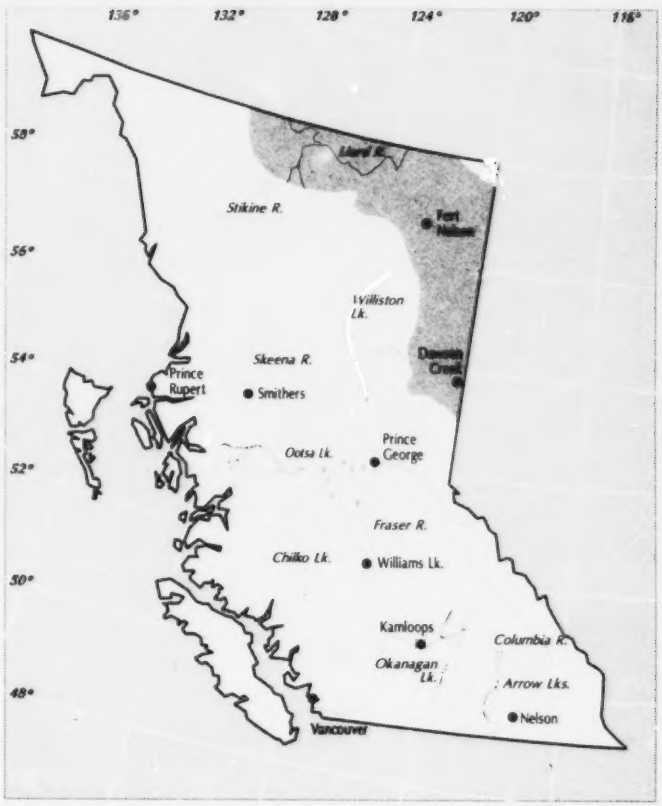
Pests Affecting Cone and Seed Production

Lt has no major cone and seed pests

Collection Notes

1) Previous years' cones may remain on the tree and should not be collected.
2) Local collection productivity information is not available.
3) Recommended collection techniques: climbing, felling.

Notes:


136°
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Liard R.
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Williston Lk.
Dawson Creek
Skeena R.
Prince Rupert
Smithers
Ootsa Lk.
Prince George
Fraser R.
Chilko Lk.
Williams Lk.
Kamloops
Okanagan Lk.
Columbia R.
Arrow Lks.
Nelson
Vancouver

Range

Larix occidentalis Nutt. - Western Larch (Lw)

Lw is found in southeastern British Columbia in the PPBG, IDF, and drier IWH biogeoclimatic zones at elevations ranging from 450 to 1800 m. It prefers moist, nutrient-rich sites, and has high frost resistance and low shade tolerance.

Cone and Seed Production Characteristics

Reproductive cycle ..... 2 years
Cone length (cm) 2-3
Cone bearing age (collectable quantities) ..... 25 years
Cones/hectolitre 10 000-15 000
Periodicity ..... 1-10 years
Viable seeds/hectolitre of cones 119 312
Position of cones in crown ..... Throughout non-shaded portion of crown
Ease of detachment ..... Moderate
Plantable trees/hectolitre of cones
Bareroot 34 000
Container 33 000

Recommended Collection Standards

Filled seeds/half-cone 6
Cone colour ..... Brown
Storage tissue ..... Opaque and firm
Seedcoat ..... Golden to reddish-brown
Embryo ..... Should occupy 90% of the cavity; pale yellow
Seedwing ..... Tan
Cleanliness ..... Less than 5% debris and unacceptable cones

Pests Affecting Cone and Seed Production

Lw has no major cone and seed pests

Collection Productivity

Collection technique	Hectolitres collected/man-day Average (range)
Felling	0.7 (0.4 - 1.2)

Collection Notes

1) Lw cones are persistent, remaining on the tree for an indefinite period, so care must be taken not to include old cones in collections. This persistence also makes it impractical to attempt to rake cones from branches.

2) The cone scales of Lw open and reclose several times before reflexing completely and releasing seeds. Therefore, the collection period is somewhat extended in comparison to other species.

3) Larch stems and branches are very brittle, so pickers must use extreme caution when climbing. Branches break off when bent toward the climber.

Many Cones

Mature Cones

Notes:

Range

Picea glauca x *engelmannii* Perry ex Engelm. - Interior Spruce (Sx)

Two species of spruce, white (*Picea glauca*) and Engelmann (*Picea engelmannii*), occur throughout much of central British Columbia. These species hybridize freely wherever their ranges overlap. Consequently, they are often referred to collectively as interior spruce. Sx grows on moist sites in the ESSF, SBS, SWB, BWBS, SBS and northern CALP biogeoclimatic zones. It generally occurs between 600 m and tree line, and has high frost resistance, low shade tolerance, and high flood resistance. It is most productive on nutrient-rich sites.

Cone and Seed Production Characteristics

Reproductive cycle	2 years
Cone length (cm)	3-6
Cone bearing age (collectable quantities)	40 years
Cones/hectolitre	10 000
Periodicity	6 years
Viable seeds/hectolitre of cones	347 163
Position of cones in crown	Top 1/3
Ease of cone detachment	Moderate
Plantable trees/hectolitre of cones	
Bareroot	84 000
Container	73 000

Recommended Collection Standards

Filled seeds/half-cone	7
Cone colour	Lustrous light brown
Storage tissue	Opaque, firm and resembling coconut meat
Seedcoat	Glossy, pale to dark brown
Seedwing	Light brown, with a dark stripe along one edge
Embryo	Should occupy 90% of the cavity; yellowish; firm
Cleanliness	Less than 5% debris and unacceptable cones

Pests Affecting Cone and Seed Production

Insects

- Coneworm (*Dioryctria abietivorella*)
- Seed chalcid (*Megastigmus piceae*)
- Spiral spruce cone borer (*Lasiomma anthracina*)
- Spruce cone axis midge (*Dasineura rachiphaga*)
- Spruce seed midge (*Mayetiola carpophaga*)
- Spruce seedworm (*Cydia strobilella*)

Diseases

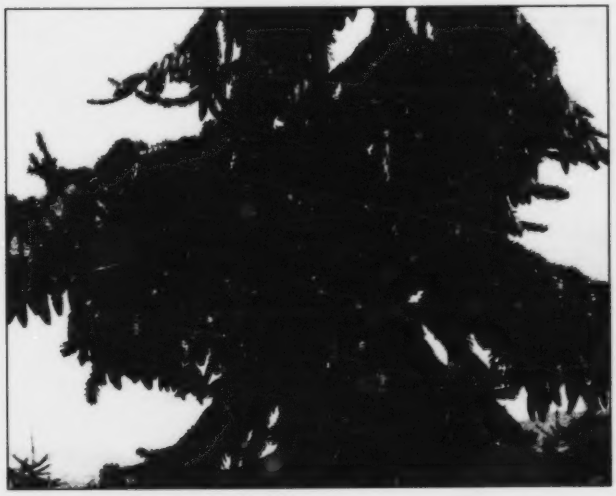
- Inland spruce cone rust (*Chrysomyxa pirolata*)
- Seed fungus or cold fungus (*Caloscypha fulgens*)

Collection Productivity

Collection technique	Hectolitres collected/man-day Average (range)
Aerial	1 (0.2 - 3.4)
Felling	1 (0.2 - 5.8)

Collection Notes

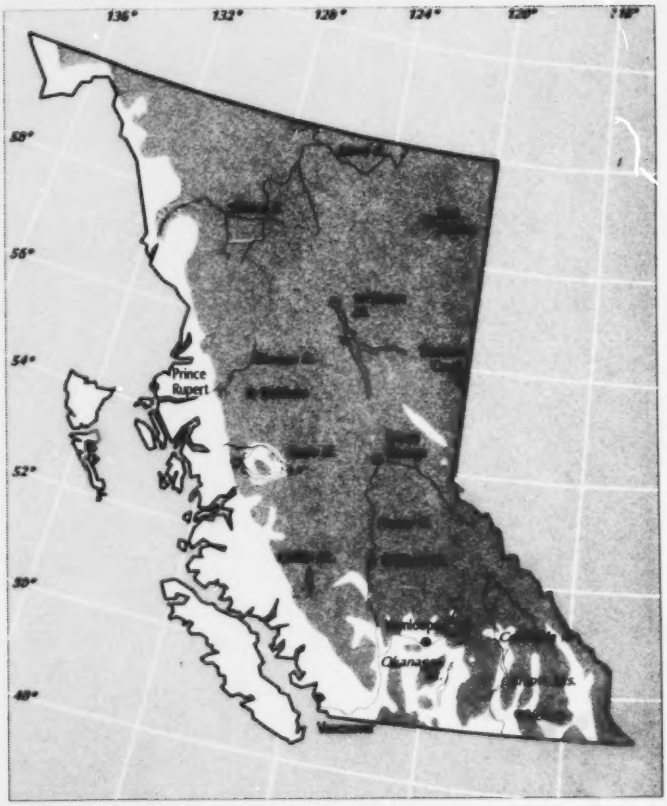
1) The embryo in an Sx seed will fill its cavity well before the seed is mature. Consequently, cones should not be collected until all maturity criteria have been met. It is generally recommended that Sx collections should begin only after some of the cones in the stand have begun to open.
2) The cone scales of Sx reflex almost completely before seeds begin to fall, so the collection period is somewhat extended in comparison to other species.
3) The embryos of Sx are extremely small and should be excised for evaluation.
4) Since Sx cones are usually quite pitchy, gloves are recommended when picking.



Many Cones

Mature Cones

Notes:



Range

Picea mariana (Mill.) B.S.P. - Black Spruce (Sb)

Sb occurs on sites in the BWBS and SWB biogeoclimatic zones where moisture is abundant. It is generally found at elevations ranging from 300 to 1000m. It is extremely resistant to frost and has high shade tolerance.

Cone and Seed Production Characteristics

Reproductive cycle	2 years
Cone length (cm)	2.5
Cone bearing age (collectable quantities)	10 years
Cones/hectolitre	19 000-45 000
Periodicity	4 or more years
Viable seeds/hectolitre of cones	108 000
Position of cones in crown	Top 1/4
Ease of cone detachment	Difficult
Plantable trees/hectolitre of cones	
Bareroot	41 000
Container	36 000

Recommended Collection Standards

Filled seeds/half-cone	7
Cone colour	Purple to black
Storage tissue	Opaque and firm
Seedcoat	Black and firm
Embryo	Should occupy 90% of the cavity; white to yellow
Seedwing	Unavailable
Cleanliness	Less than 5% debris and unacceptable cones

Pests Affecting Cone and Seed Production

Insects

- Coneworm (*Dioryctria abietivorella*)
- Spruce cone axis midge (*Dasineura rachiphaga*)
- Spiral spruce cone borer (*Lasiomma anthracina*)

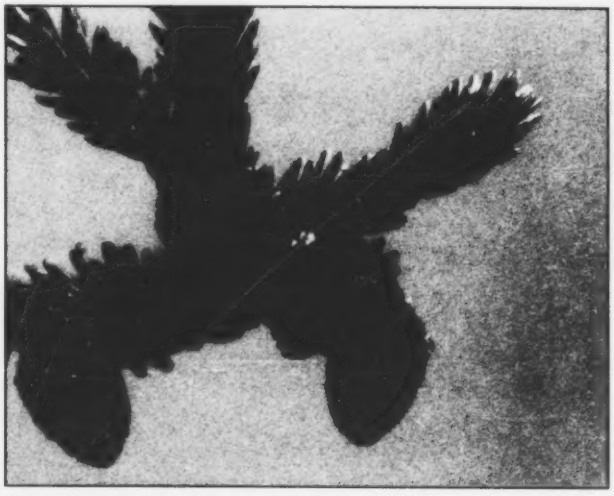
Diseases

- Inland spruce cone rust (*Chrysomyxa pirolata*)

Collection Notes

1) Sb cones are persistent and semi-serotinous. Viable seeds are shed slowly over a period of about 4 years.
2) Local collection productivity information is not available.
3) Recommended collection technique: felling.

Many Cones



Mature Cones

Notes:

Range

Picea sitchensis (Bong.) Carr. - Sitka Spruce (Ss)

Ss occupies the most humid and productive forest land along river valleys in the CWH biogeoclimatic zone. It is usually found between sea level and 800 m, and has low shade tolerance, low frost resistance, high flood resistance, and high nutritional requirements. Ss hybridizes freely with Se and Sw where their ranges overlap. The use of Ss in the province's reforestation program has been limited as a result of its susceptibility to the Sitka spruce weevil.

Cone and Seed Production Characteristics

Reproductive cycle	2 years
Cone length (cm)	5-10
Cone bearing age (collectable quantities)	25-40 years
Cones/hectolitre	4 000-6 000
Periodicity	3-4 years
Viable seeds/hectolitre of cones	194 270
Position of cones in crown	Top 1/3
Ease of cone detachment	Moderate
Plantable trees/hectolitre of cones	
Bareroot	83 000
Container	67 000

Recommended Collection Standards

Filled seeds/half-cone	7
Cone colour	Yellowish-brown
Storage tissue	Opaque and firm
Seedcoat	Golden brown to dark brown
Embryo	Should occupy 90% of the cavity
Seedwing	Golden brown with darker strip along one edge
Cleanliness	Less than 5% debris and unacceptable cones

Pests Affecting Cone and Seed Production

Insects

- Spiral spruce cone borer (*Lasiomma anthracina*)
- Spruce seedworm (*Cydia strobilella*)
- Spruce cone axis midge (*Dasineura rachiphaga*)

Diseases

- Coastal spruce cone rust (*Chrysomyxa monesis*)
- Seed fungus or cold fungus (*Caloscypha fulgens*)

Collection Notes

1) Local collection information for this species is unavailable.

Many Cones

Mature Cones

Notes:

Range

Pinus albicaulis Engelm. - Whitebark Pine (Pa)

Pa grows on moist, nutrient-rich sites in the upper subcontinental MH and the ESSF biogeoclimatic zones. It occurs at elevations ranging from 1000 to 2000 m, and is highly frost resistant and generally shade tolerant except on very dry sites.

Cone and Seed Production Characteristics

Reproductive cycle	3 years
Cone length (cm)	3-8
Cone bearing age (collectable quantities)	20-30 years
Cones/hectolitre	Unavailable
Periodicity	3-5 years
Viable seeds/hectolitre of cones	515
Position of cones in crown	Throughout
Ease of cone detachment	Difficult
Plantable trees/hectolitre of cones	
Bareroot	100

Recommended Collection Standards

Filled seeds/half-cone	Unavailable
Cone colour	Purple to brown
Storage tissue	Opaque and firm
Seedcoat	Unavailable
Embryo	Should occupy 90% of the cavity
Seedwing	Generally wingless
Cleanliness	Less than 5% debris and unacceptable cones

Pests Affecting Cone and Seed Production

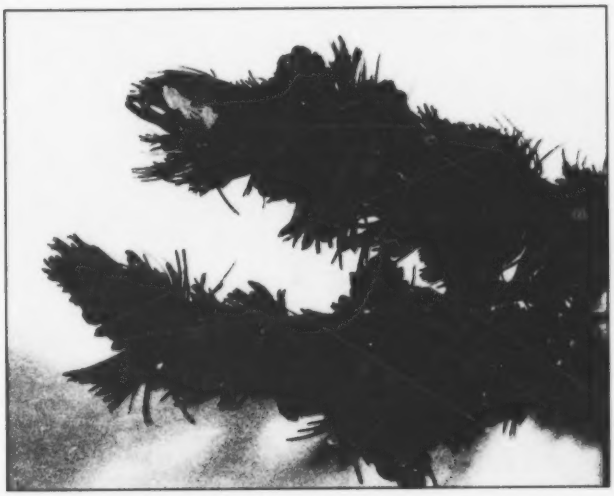
Pa has no major cone or seed pests.

Collection Notes

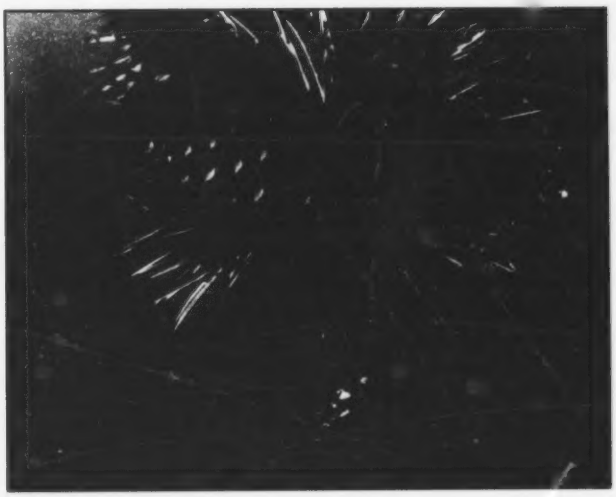
1) Pa cones remain closed after ripening, fall from the tree, and must decay on the ground before the wingless seeds are released. Because of this, the collection period is prolonged. However, the seeds are a favourite food of ravens and jays, and seed losses may occur if collections are delayed.

2) Local collection productivity information is not available.

3) Recommended collection techniques: climbing, pruning shears.



Many Cones



Mature Cones

Notes:

Range

Pinus contorta Dougl. ex Loud. - Lodgepole Pine (Pl)

Two varieties of Pl occur in British Columbia: coastal (var. *contorta*) and interior (var. *latifolia*). Both varieties have similar foliage, flowers, and cones. The coastal variety is, however, generally scrubby and of poor form and currently of only minor reforestation importance. The interior variety is of good form and is a major component of the reforestation program.

Pl grows on a wide variety of sites in the ESSF, SBS, CALP, BWBS, IDF, IWH, wetter CDF, and CWH biogeoclimatic zones. It can be found at all elevations from sea level to timberline, has moderate to high frost resistant and low shade tolerance. Cones of the coastal variety are mainly non-serotinous, whereas the interior variety usually bears serotinous cones. Cone serotiny is silviculturally important, in that large quantities of viable seeds are available for release following a wild fire or cutting. In both varieties, cones persist on the trees for many years, but only freshly-ripened cones have the highest numbers of viable seeds. This makes cone selection an important feature of lodgepole pine collections.

Cone and Seed Production Characteristics

Reproductive cycle	3 years
Cone length (cm)	3-6
Cone bearing age (collectable quantities)	15-20 years
Cones/hectolitre	8 300
Periodicity	2-4 years
Viable seeds/hectolitre of cones	
Coast	176 660
Interior	70 546
Position of cones in crown	Throughout
Ease of cone detachment	Difficult except when frozen
Plantable trees/hectolitre of cones	
Coast	
Bareroot	43 000
Container	25 000
Interior	
Bareroot	29 000
Container	21 000

Pests Affecting Cone and Seed Production

Insects:

Pine cone moth (*Eucosma recissoriana*)

Recommended Collection Standards

Filled seeds/half-cone	*5
Filled seeds/whole cone	20
Cone colour	Shiny, golden brown
Storage tissue	Opaque and firm
Seedcoat	Dark brown to black; may be mottled
Embryo	Should occupy 90% of the cavity; white
Seedwing	Light brown
Cleanliness	Less than 5% debris and less than 25% Class II and IV cones

* Cut transversely at 1/2 cone length.

Collection Productivity

Collection technique	Hectolitres collected/man-day Average (range)
Aerial	1 (0.4 - 1.2)
Felling	0.7 (0.2 - 3.5)

Collection Notes

1) In interior Pl, filled seeds are generally found in only the top 1/3 to 1/2 of the cone, whereas in the coastal variety, filled seeds occur throughout the cone.

2) As a result of the lack of colour contrast between the embryo and endosperm in Pl, embryos must be excised to assess maturity accurately. This is very important, because in some situations, embryos may be missing.

3) Pl seeds can be extracted from closed cones for evaluation by dipping the cones in near-boiling water for about 1 minute, or until the cracking sound stops, and then heating them in a microwave oven at full power for 1-1.5 minutes. Care should be taken not to overheat, and hence damage, the seeds. Damage will be indicated by a fatty smell.

4) Insect damage in Pl tends to be minimal and is generally in the form of boring at the base of the cones.

5) Cones are usually picked from felled trees. Cones are persistent and picking is easier when temperatures are below -15°C, since the cone stalks are then brittle.

6) For the interior variety, in which the cones are mainly serotinous, the following classes have been defined:

(illustrations are provided on page 72.)

Cones to be collected

Class I
- freshly-ripened, current year's cones
- usually brown, bronze or gold colour on all faces, and tightly closed
- cone age, 2 years
- do not collect when cones are olive in colour, as the seeds are not fully mature

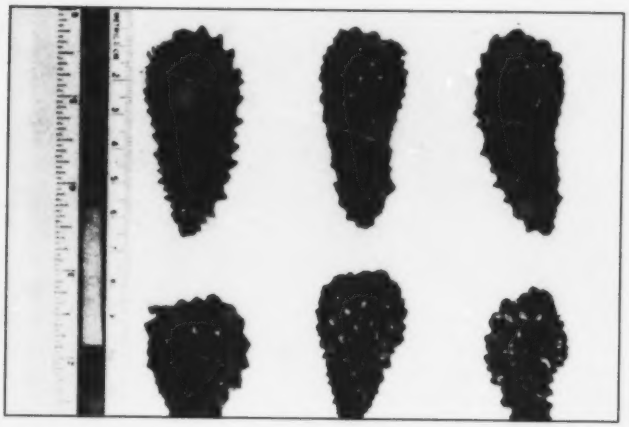
Class II
- partially-weathered, closed cones
- usually bronze, brown, or gold on one face and grey (weathered) on other faces
- cones tightly closed
- cone age, approximately 3-5 years

In undisturbed stands, only a few cones open after ripening at normal temperatures. A fire or logging disturbance is usually required to open and disperse seeds from serotinous cones.

Cones NOT to be collected

Class III
- fully weathered, closed cones
- generally grey in colour and most faces of the cones appear weathered
- cones tightly closed
- cone age definitely greater than Class II cones
- non-serotinous cones usually open at maturity at normal temperature in undisturbed stands

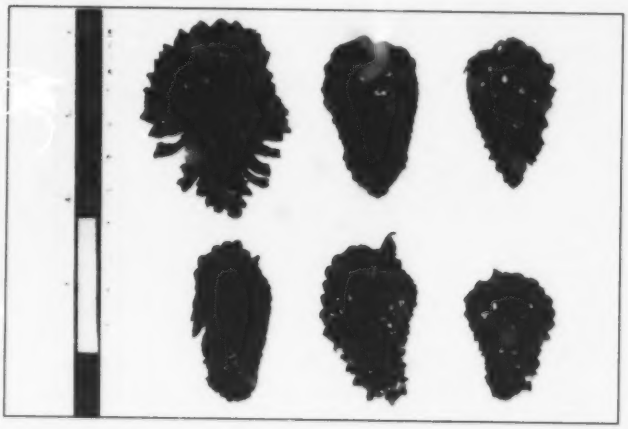
Class IV
- partially-opened or opened, old or new cones
- cones variable in colour, but have opened or partially opened and some or all seeds have been dispersed



Class I

Class II

Class III

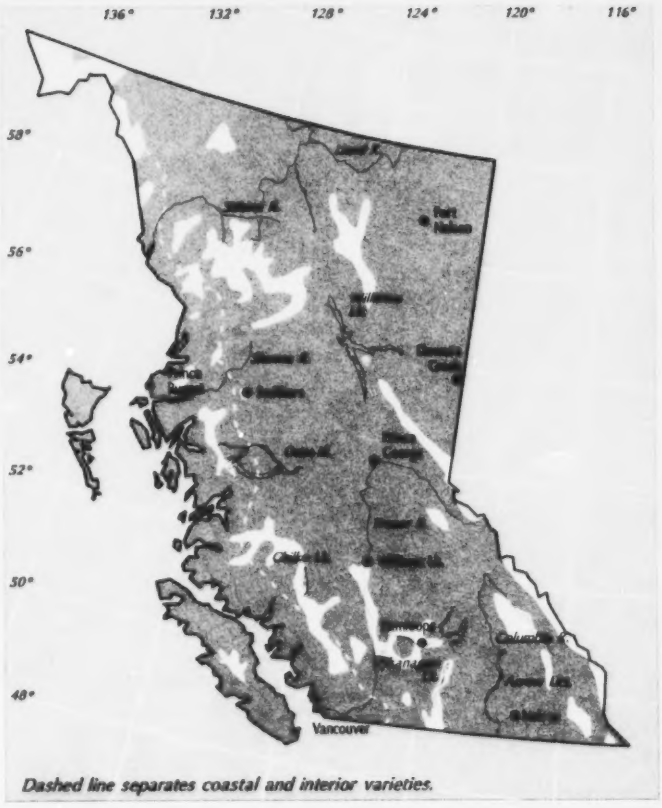


Class IV

Many Cones

Mature Cones

Notes:



Dashed line separates coastal and interior varieties.

Range

Pinus flexilis James - Limber Pine (Pf)

Pf is a minor species in British Columbia and is found only in the southeastern corner of the province, at elevations of 1000-2000 m. It grows best on moist, nutrient-rich sites in the ESSF biogeoclimatic zone. It has high frost resistance and is shade intolerant.

Cone and Seed Production Characteristics

Reproductive cycle	3 years
Cone length (cm)	7-20
Cone bearing age (collectable quantities)	20-40 years
Cones/hectolitre	Unavailable
Periodicity	2-4 years
Viable seeds/hectolitre of cones	6 454
Position of cones in crown	Throughout
Ease of cone detachment	Moderate
Plantable trees/hectolitre of cones	
Bareroot	4 000
Container	2 000

Recommended Collection Standards

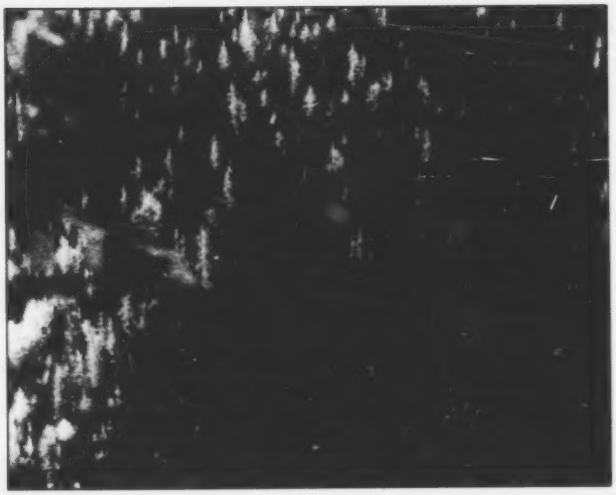
Filled seeds/half-cone	Unavailable
Cone colour	Lustrous yellowish to light brown
Storage tissue	Opaque and firm
Seedcoat	Light brown
Embryo	Should occupy 90% of the cavity
Seedwing	Wingless
Cleanliness	Less than 5% debris and unacceptable cones

Pests Affecting Cone and Seed Production

Pf has no major cone or seed pests.

Collection Notes

1) Old Pf cones, recognizable by their grey-brown "weathered" appearance and open scales, should not be collected.
2) Local collection productivity information is not available.
3) Recommended collection techniques: climbing, pruning shears.



Many Cones

Mature Cones

Notes:

Range

Pinus monticola Dougl. ex D.Don in Lamb. - Western White Pine (Pw)

Pw grows on a wide variety of soils and sites in the ESSF (lower elevations), IDF (wetter subzones), IWH, and CWH biogeoclimatic zones throughout southern British Columbia. On the coast, this species can be found from sea level to timberline. In the Interior, Pw generally occurs at elevations ranging from 300-1700 m. It is a fast-growing tree, generally overtopping its competitors on most sites. It is severely affected by calcium shortages which cause root dieback and, in some cases, crown dieback through chlorosis and subsequent necrosis. This species is also highly susceptible to white pine blister rust, and infected trees often fail to reach merchantable size. Consequently, reforestation of Pw has been limited. Advances in tree breeding and the production of rust-resistant Pw should dramatically increase the future use of this species.

Cone Production Characteristics

Reproductive cycle	3 years
Cone length (cm)	10-25
Cone bearing age (collectable quantities)	20 years
Cones/hectolitre	250-350
Periodicity	3-7 years
Viable seeds/hectolitre of cones	7 587
Position of cones in crown	Top 1/4
Ease of cone detachment	Moderate
Plantable trees/hectolitre of cones	
Bareroot	5 000
Container	4 000

Recommended Collection Standards

Filled seeds/half-cone	10
Cone colour	Beige, brown or purplish-brown
Storage tissue	Opaque and firm
Seedcoat	Light to dark brown and often darkly mottled
Embryo	Should occupy 90% of the cavity; opaque and yellowish in colour, and easily separated from the storage tissue
Seedwing	Tan and darker along the straight edge and tip
Cleanliness	Less than 5% debris and unacceptable cones

Pests Affecting Cone and Seed Production

Insects

Pine cone beetle (*Conophthorus monticolae*)

Collection Productivity

Collection technique	Hectolitres collected/man-day Average (range)
Aerial	3.3 (1.4 - 6.3)
Climbing	1.4 (0.6 - 2.3)
Felling	2.5 (1.2 - 4.5)

Collection Notes

1) Cones should be collected from trees that are 25-55 years of age and that show no symptoms of rust on any branches or the stem (MOFL, White Pine Policy Statement - 1983), i.e., from the surviving trees in heavily infected stands. The surviving trees are likely to be more resistant to the disease and, therefore, their seeds are also more likely to have higher resistance than seeds collected from infected immature trees. Infected trees should be marked and excluded from the collection (Meagher, Hunt and Wallinger 1987).

2) Occasionally, greenish Pw cones may contain mature seeds, so repeated seed cutting tests are necessary to determine collection timing.

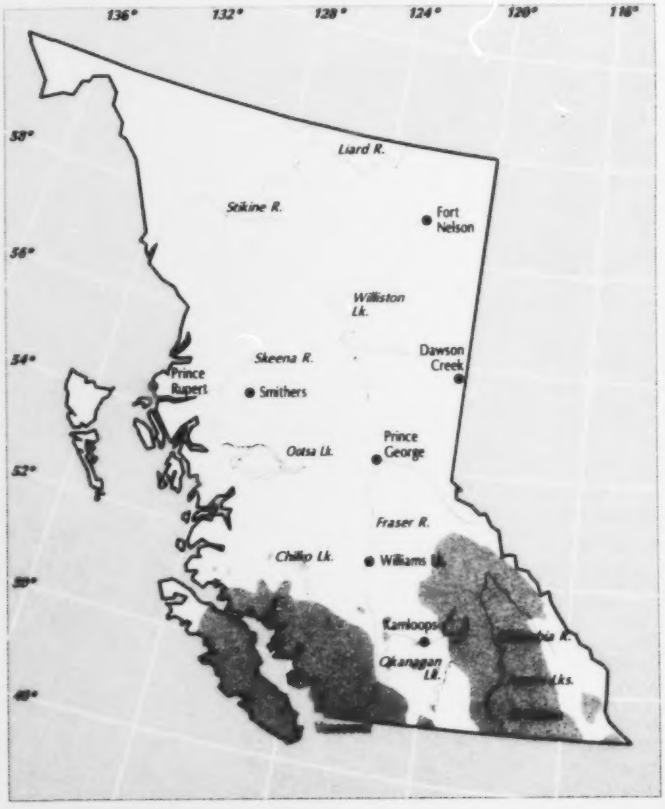
3) Once mature, Pw cones tend to open quickly. Constant monitoring and good pre-collection organization are essential to ensure that seeds can be collected promptly upon maturation.

4) Because Pw cones are very resinous, gloves are recommended for pickers.

Many Cones

Mature Cones

Notes:



Range

Pinus ponderosa Dougl. ex P. & C. Lawson - Ponderosa Pine (Py)

Py is found in the south-central and southeastern parts of the province, at elevations of 250-1200 m. It generally occurs in pure, open, park-like stands on nutrient-rich sites in the dry PPBG and IDF biogeoclimatic zones. It has very low shade tolerance, moderate frost resistance, and relatively high flood resistance.

Cone and Seed Production Characteristics

Reproductive cycle	3 years
Cone length (cm)	7-9
Cone bearing age (collectable quantities)	12-16 years
Cones/hectolitre:	700
Periodicity	4-6 years
Viable seeds/hectolitre of cones	31 522
Position of cones in crown	Throughout
Ease of cone detachment	Difficult
Plantable trees/hectolitre of cones	
Bareroot	2 000
Container	7 000

Recommended Collection Standards

Filled seeds/half-cone	7 (or 75 per whole cone)
Cone colour	Lustrous yellow-brown
Seedcoat	Pale brown to brown and usually mottled; very hard and difficult to cut
Storage tissue	Opaque and firm
Embryo	Should occupy 90% of the cavity; yellow
Seedwing	Tan
Cleanliness	Less than 5% debris and unacceptable cones

Pests Affecting Cone and Seed Production

Insects

Ponderosa pine cone moth (*Cydia piperana*)
Pine coneworms (*Dioryctria abietivorella & D. auranticella*)
Cone scale midge (*Resseliella spp.*)

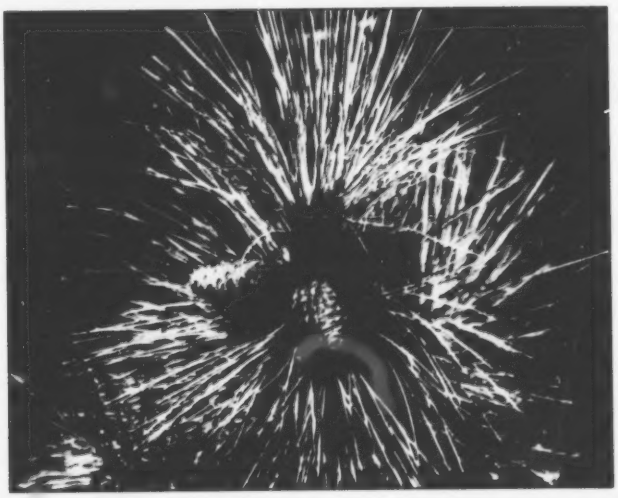
Collection Productivity

Collection technique	Hectolitres collected/man-day Average (range)
Aerial	0.8 (0.3 - 1.4)
Felling	1 (0.8 - 1.3)

Collection Notes

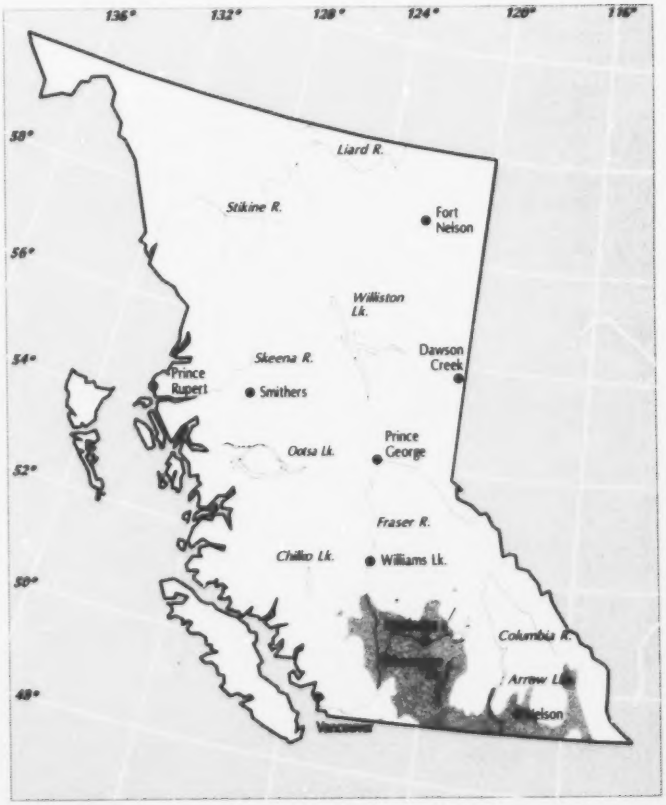
1) Py seeds can be extracted for evaluation by heating sample cones in a microwave oven at full power for approximately 1-2 minutes. Care must be taken not to damage the seeds by leaving the cones in the oven for too long; damage is indicated by a fatty smell.
2) Py branches are brittle, so pickers must take extra care when climbing.
3) Cones should be bent toward the end of the branch to break the stalk. They can also be knocked or shaken off and gathered from the ground later.
4) Because cones have sharp barbs protruding from the scales, pickers must use gloves.

Many Cones



Mature Cones

Notes:



Range

Pseudotsuga menziesii (Mirb.) Franco - Douglas-fir (Fd)

Two forms of Fd, coast and interior, are generally recognized in British Columbia. The coastal form can be found at elevations ranging from sea level to 1200 m; the interior form occurs to 1500 m. Fd grows on a variety of sites in the southern CALP, IDF, IWH, CDF, and southern CWH biogeoclimatic zones. It also occurs to a lesser extent in the southern MH, lower ESSF, SBS, PPBG, and northern CALP. The interior form is more frost resistant than the coastal form, but does not grow as quickly. Fd is considered to have moderate shade tolerance and nutritional requirements. Calcium deficiencies result in dieback, and shortages of magnesium cause reductions in diameter growth. Nitrates are required for best growth. This species is also thought to have the lowest flood resistance of all trees growing in British Columbia.

Cone and Seed Production Characteristics

Reproductive cycle	2 years
Cone length (cm)	5-10
Cone bearing age (collectable quantities)	20-25 years
Cones/hectolitre	2 800
Periodicity	2-10 years
Viable seeds/hectolitre of cones	
Coast	39 577
Interior	70 343
Position of cones in crown	Top 1/2
Ease of cone detachment	Easy
Plantable trees/hectolitre of cones	
Coast	
Bareroot	3 000
Container	9 000
Interior	
Bareroot	20 000
Container	14 000

Pests Affecting Cone and Seed Production

Insects

Cone scale midge (*Camptomyia pseudotsuga*)
Douglas-fir cone moth (*Barbara* spp.)
Douglas-fir cone gall midge (*Contarinia oregonensis*)
Douglas-fir cone scale midge (*Contarinia washingtonensis*)
Douglas-fir cone beetle (*Ernobius punctulatus*)
Douglas-fir seed chalcid (*Megastigmus spermatrophus*)
Douglas-fir twig mining beetle (*Pityophthorous orarius*)
Fir coneworm (*Dioryctria abietivorella*)
Western spruce budworm (*Choristoneura occidentalis*)

Diseases

Seed fungus or cold fungus (*Caloscypha fulgens*)

Recommended Collection Standards

Filled seeds/half-cone	5
Cone colour	Golden brown
Storage tissue	Opaque and firm
Embryo	Should occupy 90% of the cavity; pale yellow
Seedcoat	Tan to golden and often variegated on one side; the other side may be glossy and darker
Seedwing	Golden brown and easily detached from the cone scale
Cleanliness	Less than 5% debris and unacceptable cones

Collection Productivity

Collection technique	Hectolitres collected/man-day Average (range)
Aerial	1.6 (0.1 - 3.6)
Climbing	1.2 (0.4 - 2.0)
Felling	1.4 (0.5 - 3.3)

Collection Notes

1) Fd embryos may fill their cavities well before seeds are mature, so cones should not be collected until all maturity criteria have been met.

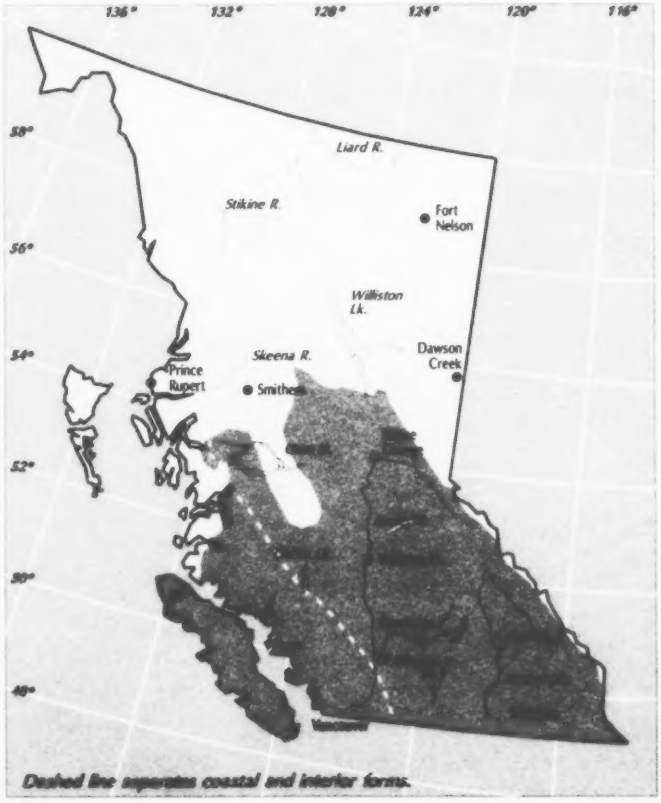
2) Cone bracts may still be green at maturity, but scales should be separating before collection. The cone scales of Fd reflex almost completely before seeds begin to fall, so the collection period is somewhat extended in comparison to other species.

3) Cones should not be collected from trees heavily infested with dwarf mistletoe.

Many Cones

Mature Cones

Notes:



Range

Thuja plicata Donn. ex D. Don in Lamb. - Western Redcedar (Cw)

Cw is confined almost entirely to regions with abundant precipitation and atmospheric humidity, preferring moist sites in the IWH, CDF, CWH and IDF biogeoclimatic zones. It generaly occurs below 1500 m, and has low frost resistance, high shade tolerance, and high flood resistance. Cw grows best on nutrient-rich sites.

Cone and Seed Production Characteristics

Reproductive cycle	2 years
Cone length (cm)	1-2
Cone bearing age (collectable quantities)	20-30 years
Cones/hectolitre	110 000
Periodicity	2-4 years
Viable seeds/hectolitre of cones	897 837
Position of cones in crown	Throughout
Nursery factor	0.250
Ease of cone detachment	Easy
Plantable trees/hectolitre of cones	
Bareroot	266 000
Container	258 000

Recommended Collection Standards

Filled seeds/half-cone*	2
Cone colour	Golden to cinnamon brown
Storage tissue	Opaque and firm
Seedcoat	Light to dark brown; soft
Seedwing	Light brown
Embryo	Should occupy 90% of its cavity in length; white
Cleanliness	Less than 10% debris and unacceptable cones

*Cut transversely at 1/2 cone length.

Pests Affecting Cone and Seed Production

Insects

Redcedar cone midge (*Mayetiola thujae*)

Collection Productivity

Collection technique	Hectolitres collected/man-day Average (range)
Aerial	0.08 (0.04 - 0.25)
Felling	0.2 (0.04 - 1.6)

Collection Notes

1) Current cones are borne very near branchlet tips. Old cones, distinguishable by their weathered, grey-brown colour and open scales, are found further along the branch and should be avoided.

2) When the cutting test is performed on Cw, the basal area of the cone must also be examined for potential midge damage.

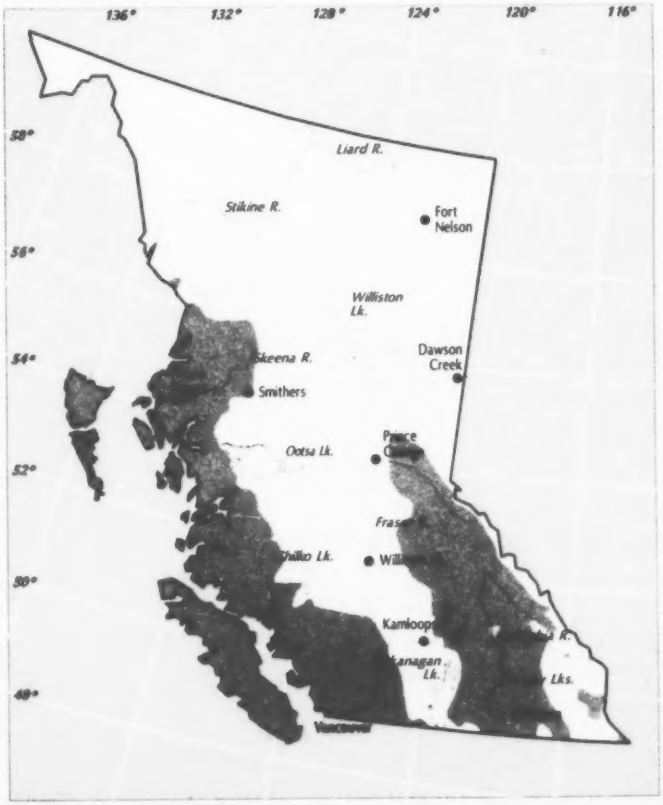
3) Cw cones should be loosely sacked (20 litres/sack) to prevent overheating and pre-germination.

4) Cw has low seed dormancy and is subject to pre-germination. Cones should be forwarded to the processing facility immediately after collection to ensure that pre-conditioning can be carried out in a controlled environment.

Many Cones

Mature Cones

Notes:



Range

Tsuga heterophylla (Raf.) Sarg. - Western Hemlock (Hw)

Hw grows in areas of high mean annual percipitation in the IWH, CWH, and, to a lesser extent, CDF biogeoclimatic zones. It can be found at elevations up to 1200 m at the coast and to 1500 m in the Interior. It has little resistance to frost unless the ground is well covered with snow before freezing, but it has high shade tolerance and flood resistance. The nutritional requirements of Hw are low. While Hw hybridizes with Hm, such hybrids rarely produce cones.

Cone and Seed Production Characteristics

Reproductive cycle	2 years
Cone length (cm)	2-3
Cone bearing age (collectable quantities)	25-30 years
Cones/hectolitre	83 000
Periodicity	3-4 years
Viable seeds/hectolitre of cones	366 698
Cleaned seeds/gram	489
Position of cones in crown	Throughout
Ease of cone detachment	Easy
Plantable trees/hectolitre of cones	
Bareroot	93 000
Container	98 000

Recommended Collection Standards

Filled seeds/half-cone	3
Cone colour	Purplish or yellow-brown;
Storage tissue	Opaque and firm often with reddish brown tips
Embryo	Should occupy 90% of the cavity
Seedcoat	Brown to dark brown; soft
Seedwing	Light brown
Cleanliness	Less than 10% debris and unacceptable cones

Pests Affecting Cone and Seed Production

Insects

Seed chalcid (*Megastigmus tsugae*)

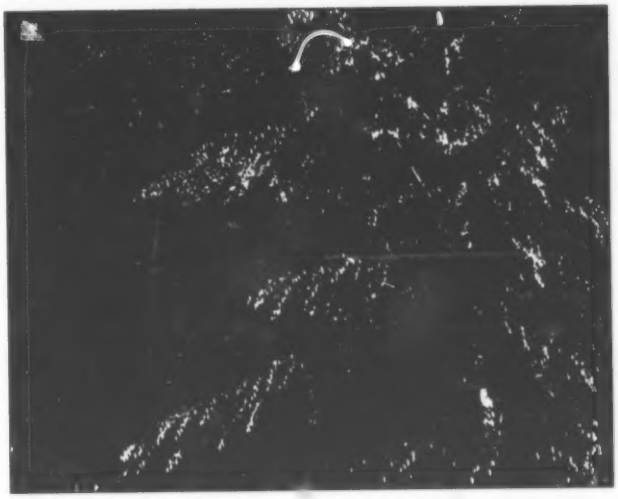
Collection Productivity

Collection technique	Hectolitres collected/man-day Average (range)
Aerial	0.2 (0.04 - 0.52)
Felling	0.2 (0.05 - 0.75)

Collection Notes

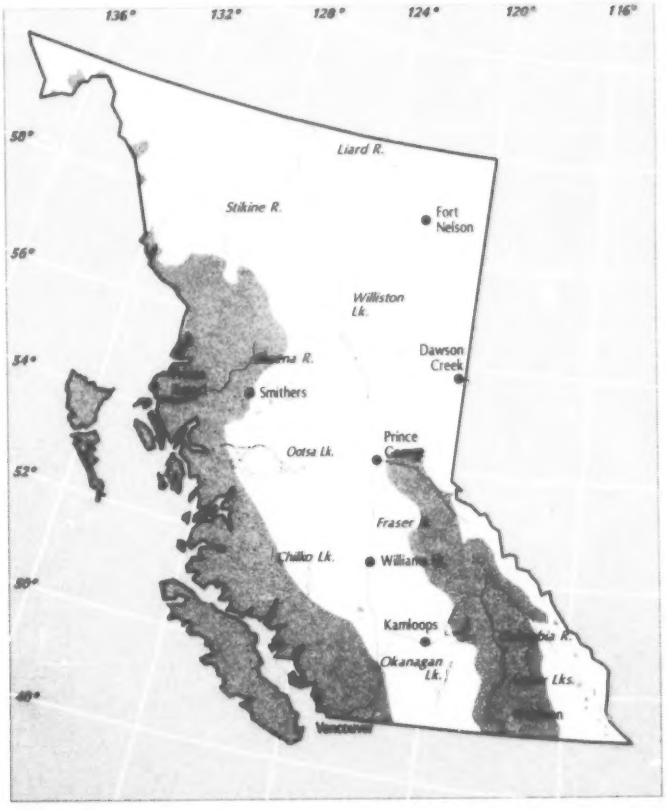
1) Old Hw cones, recognizable by their dark greyish/brown colour and their "open" scales, should be avoided.
2) Cone scales should be separating at the time of collection.
3) Since Hw seeds germinate quickly in cool, moist conditions, cones should be sent to the processing facility immediately after collection to ensure that pre-conditioning can be carried out in a controlled environment.
4) Hw cones should be loosely sacked (20 litres/sack) to prevent overheating and pre-germination.
5) If cones are picked too early, problems with cone opening may be encountered at the extractory.
6) Cone rakes may be used when picking is done from felled trees.
7) Hw seeds generally mature later in the fall (October) than do seeds of other species.

Many Cones



Mature Cones

Notes:



Range

Tsuga mertensiana (Bong.) Carr. - Mountain Hemlock (Hm)

Hm is found on moist sites in the MH and wetter ESSF biogeoclimatic zones, at elevations ranging from 1000 to timberline. It is not frost resistant or flood resistant, but it is shade tolerant and has low nutritional requirements. Hm is better adapted to snowy subalpine climates than is Hw. Hm and Hw hybridize where their ranges overlap, but cone production by these hybrids is rare.

Cone and Seed Production Characteristics

Reproductive cycle	2 years
Cone length (cm)	2-8
Cone bearing age (collectable quantities)	30 years
Cones/hectolitre	Unavailable
Periodicity	3-6 years
Viable seeds/hectolitre of cones	356 428
Position of cones in crown	Top 1/3
Ease of cone detachment	Easy
Plantable trees/hectolitre of cones	
Bareroot	87 000
Container	95 000

Recommended Collection Standards

Filled seeds/half-cone	Unavailable
Cone colour	Light purple to brownish-purple
Storage tissue	Opaque and firm
Seedcoat	Golden to reddish brown
Embryo	Should occupy 90% of the cavity; pale yellow
Seedwing	Tan
Cleanliness	Less than 5% debris and unacceptable cones

Pests Affecting Cone and Seed Production

Hm has no major cone or seed pests.

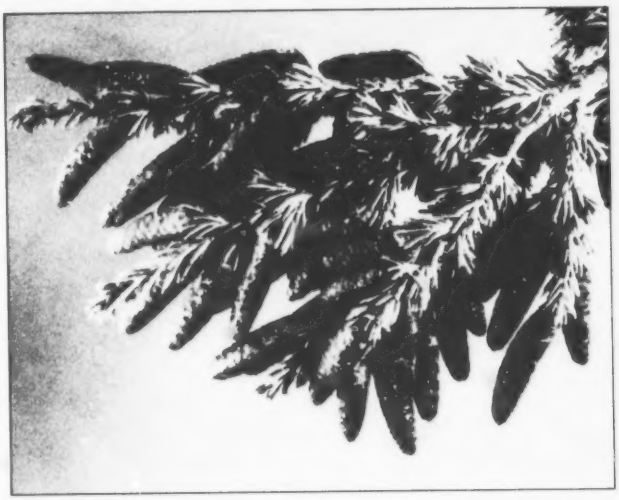
Collection Productivity

Collection technique	Hectolitres collected/man-day Average (range)
Aerial	0.8 (0.5 - 1)

Collection Notes

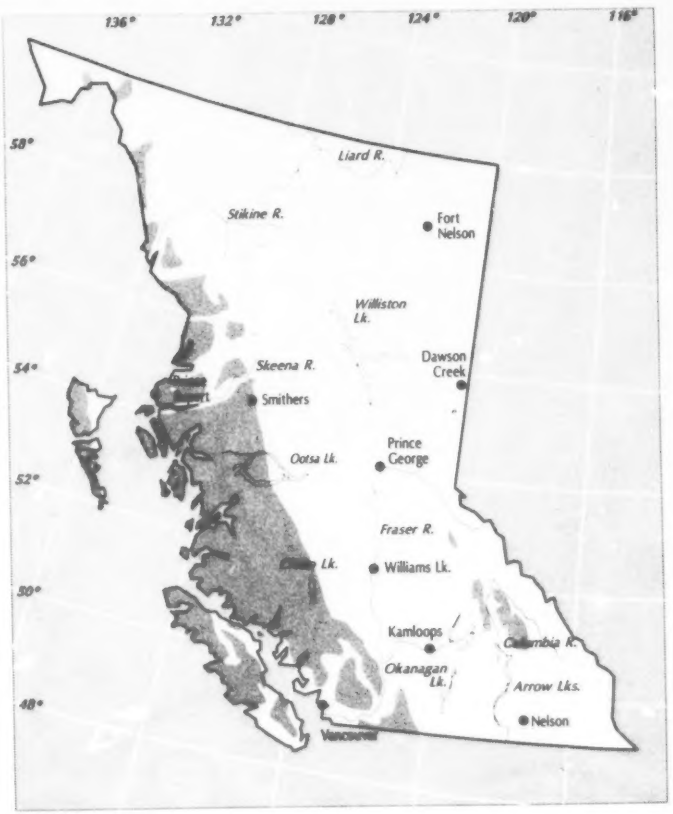
1) The cone scales of Hm reflex almost completely before seeds begin to fall, so the collection period is somewhat extended in comparison to that for other species.

Many Cones



Mature Cones

Notes:



Range

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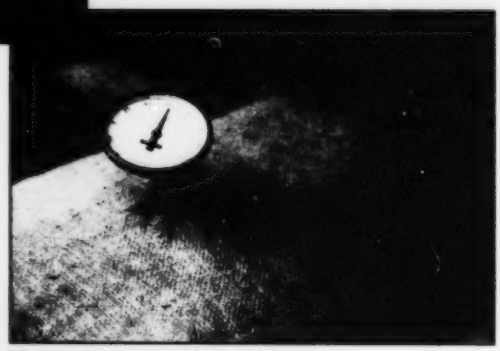
APPENDICES

An interim cone storage facility



Monitoring cone temperature

Squirrel with cone

Surveying the cone crop

Aerial clipping

APPENDIX 1 Glossary

Apices	- growing points, or zones of cell division, at the tips of stems and roots in vascular plants.
Bract	- a modified leaf which extends underneath a scale in female cones.
Cone	- the reproductive structure of conifers. (see also Pollen cone, Seed cone.)
Cotyledons	- primary leaves of an embryo or seedling which degenerate soon after the plant produces the first true leaves.
Caseharden	- inability of cone scales to reflex, caused by rapid drying of the outer layers while the inner layers remain moist, thereby preventing the further exit of moisture.
Diploid	- an organism or cell having double the basic or haploid number of chromosomes (usually abbreviated as 2N), characteristic of almost all vascular plant cells except gametes.
Dormancy	- a physiological state in which a seed that is capable of germination does not germinate, even in the presence of favourable environmental conditions.
Embryo	- the product of fusion of a male gamete with an ovule during fertilization (2N). In conifers, the embryo is enclosed by storage tissue and the seedcoat, and under favourable conditions grows into a new plant.
Empty seed	- a seed that does not contain all tissues essential for germination.
Endosperm	- a commonly used, but incorrect, term applied to the nutrient storage tissue (1N) surrounding the embryo in gymnosperm seeds. This tissue, which is the megagametophyte, serves the same function as the endosperm of angiosperm seeds. However, fertilization is not required for this tissue to form in gymnosperm seeds.
Fertilization	- penetration of a pollen tube into the ovule and union of the male and female nucleii.
Filled seed	- a seed containing all tissues essential for germination. (Also used in cone evaluation (p. 22) to describe a seed containing storage tissue, but not necessarily an embryo, since the latter is not checked for.)
Gamete	- sex cell (1N) capable of fusion with another gamete to produce a fertilized zygote (2N).
Gametophyte	- haploid plant (1N) which produces gametes (1N) by mitosis.

Genotype	- an individual organism's hereditary constitution which may or may not be expressed phenotypically.
Germination	- growth of an embryo resulting in its emergence from the seed.
Haploid	- an organism or cell having only one complete set of chromosomes, ordinarily half the normal diploid number (usually abbreviated as 1N). It is characteristic of gametes of vascular plants.
Integument	- the layer of tissue in conifers that encloses the nucleus of an ovule, and which develops into the seedcoat.
Internode	- that part of a plant stem separating two distinct whorls of branches.
Megaspore	- first cell of the female gametophyte which eventually becomes the embryo sac.
Megasporangia	- ovules.
Megasporophyll	- modified leaf, or cone scale, bearing megasporangia.
Megagametophyte	- haploid (1N) nutrient storage tissue in coniferous seeds. This tissue is often mistakenly called the "endosperm" in conifers. In this guide, it is called "storage tissue."
Meiosis	- a series of complex nuclear changes within the original cell, resulting in the production of new cells with half the number (1N) of chromosomes characteristic of the original cell.
Microspore	- first cell of the male gametophyte which eventually becomes a pollen grain.
Microsporangia	- pollen sacs.
Microsporophyll	- modified leaf, or scale, bearing microsporangia.
Mitosis	- a process of precise duplication of genetic material in which the cell nucleus divides into two new nuclei, each of which has the same number (2N) of chromosomes as the original cell.
Nucleus	- a dense, spherical, somewhat transparent, body in the protoplasm of plant and animal cells, which contains chromosomes.
Ovule	- a female organ surrounded by integument, within which an egg cell (1N) is produced, and which matures into a seed (2N) following fertilization.
Periodicity	- the interval (in years) between good cone crops. Some trees in a stand, or area, may bear cones every year, but heavy crops are periodic, usually occurring several years apart.
Phenotype	- all characteristics – morphological, anatomical, and physiological – of a plant, determined by the interaction between genotype and environment.

Pollen cone	- the male reproductive structure of conifers, which produces pollen grains. It consists of an axis bearing spirally arranged scales, each of which supports two pollen sacs containing pollen.
Pollination	- the transfer of pollen from the pollen cone to the receptive part of the seed cone.
Primordia	- rudimentary structures, structures at their earliest stages of development.
Progeny	- offspring of plants.
Provenance	- the geographical area (latitude, longitude, and elevation) and environment to which the parent trees are native, and within which their genetic constitution has evolved through natural selection.
Seed	- a matured ovule containing an embryo and nutritive tissue enclosed by a protective seedcoat, which is capable of developing into a plant under suitable conditions.
Seedcoat	- the protective outer layer of a seed derived from the integument of the ovule.
Seed cone	- the female reproductive structure of conifers, which produces seeds. It consists of an axis that supports spirally-arranged bracts, with ovuliferous scales at the base of each bract. Two ovules, which become seeds after fertilization occurs, are attached to the upper surface of each ovuliferous scale.
Seedlot	- a quantity of seeds of the same species, provenance, date of collection and handling history, and which is identified by a single number.
Seed orchard	- specially selected collection of trees, planted in an orchard fashion, established to produce seeds, usually of improved genetic quality. Seed orchards may be clonal (i.e. propagated from scions and produced from grafts or rooted cuttings) or seedling (i.e. propagated from seeds). An orchard may be described as first generation (from untested [natural stand] parents) or as advanced generation (the offspring of superior parents selected from a genetic test plantation). Some orchards may be established to produce seeds of species that do not produce adequately in natural stands.
Seed production stand	- a forest stand reserved and managed as a source of seeds.
Seed planning zone	- in accordance with seed transfer rules, an area throughout which seeds of a given provenance may be transferred and in which the resulting seedlings can be expected to perform adequately.

Seed source - the place (latitude, longitude, and elevation) at which seeds are collected. The source of a seed collection may not be identical with its provenance.

Serotinous - a term applied to cones that remain on the parent tree, without opening, for a year or more after the seeds inside have matured.

Zygote - diploid cell (2N) resulting from the fusion of two haploid gametes (1N), the product of fertilization.

APPENDIX 2 Pests

INSECTS

Barbara spp. (cone moths)

Larvae	Damage	Species affected
- white with dark head - pupate in mid-summer - overwinter in cocoon constructed perpendicular to the cone axis	- attacks scales and seeds - extensive, often destroying up to 50% of the cone crop - cones are pitchy, brown and often distorted	- Bg, Fd

Camptomyia pseudotsuga (cone scale midge)

Larvae	Damage	Species affected
- similar to *Contarinia oregonensis*	- occurs only in cones infested by larvae of *Contarinia oregonensis*	- Fd

Choristoneura occidentalis (western spruce budworm)

Larvae	Damage	Species affected
- body colour varying longitudinal bands of darker and lighter shades - shiny yellow to brownish black head capsule - pupate by mid-summer	- male and female flowers completely consumed or holes bored into developing cones	- Fd

Conophthorus monticolae (pine cone beetle)

Larvae	Damage	Species affected
- white - feed inside cone from mid-June to mid-July, after which they pupate for 1 week	- tunnels through conductive tissue at base of cone, killing it - cones appear shrivelled and brown - cones completely destroyed internally	- Pw

Contarinia spp. (Douglas-fir cone gall and scale midges)

C. oregonensis

Larvae	Damage	Species affected
- orange - tunnel into scale tissue in early June - form gall - lie in U-shape - drop to litter in fall	- seeds may become fused to scales or may be completely destroyed - scales die and turn red in July or August	- Fd

C. washingtonensis

Larvae
- deep orange
- tunnel into scale
- do not form galls
- lie fully extended
- emerge after cones reach maturity

Damage
- no direct damage to seeds
- if infestation severe, cone scales die and turn red in July or August

Species affected
- Fd

***Cydia* spp. (seedworms)**

Larvae
- white with dark head
- after seeds mature, larvae tunnel into cone axis where they overwinter

Damage
- no external evidence
- feed almost entirely on seeds
- seed pairs on same scale may become fused by silk-lined tunnels
- destroyed seed filled with frass

Species affected
- Py, Sb, Ss

***Dasineura* spp. (cone midge)**

Larvae
- yellow-orange
- feed in single seed
- drop to ground in fall as cone disintegrates
- pupate in litter, overwinter

Damage
- no external evidence
- seeds may be destroyed or fused to cone scale
- generally light

Species affected
- Ba, Bg, Bl, Sb, Sx, Ss

***Dioryctria* spp. (coneworms)**

Larvae
- reddish with brown head
- mine cone, severing cone scales

D. abietivorella
-pupate in cocoons on ground

D. auranticella
- pupate and overwinter in tunnel cavities

Damage
- cone scales die and turn brown
- cones badly distorted
- cones usually do not open

Species affected

D. abietivorella
- Fd, Py, Pw, Sb

D. auranticella
- Py

***Earomyia spp.* (cone maggots)**

Larvae
- white with black mouth hooks
- move through cone axis
- feed on seeds until late summer
- pupate and overwinter in litter

Damage
- no external evidence
- internal destruction of cones and seeds

Species affected
- Ba, Bg, Bl

***Ernobius punctulatus* (Douglas-fir cone beetle)**

Larvae	Damage	Species affected
- curved, white with yellowish brown head - feed in mature or dead cones	- none to living cones - complete destruction of cone	- Fd

***Eucosma recissoriana* (lodgepole pine cone moth)**

Larvae	Damage	Species affected
- dirty white - feeds on scales and seeds - pupates and overwinters in cocoon in litter	- holes and frass on surface of cones - destruction of seeds and scales	- Pl

***Lasiómma anthracina* (spiral spruce cone borer)**

Larvae	Damage	Species affected
- white - constructs spiral tunnel around cone axis - leaves cone by mid-summer - pupates and overwinters in the litter - major pest of spruce cones	- no external damage until larvae emerge - spiral borings around cone axis - seeds and scales damaged - single larva may destroy more than half of the seeds in one cone	- Sb, Sx, Ss

***Leptoglossus occidentalis* (cone bug)**

	Damage	Species affected
	- adult bug sucks juices from developing seeds	- Fd, Pl, Py, Pw

***Mayetiola* spp. (midges)**

M. carpophaga

Larvae	Damage	Species affected
- yellowish pink - enters seed, feeds and forms cocoon by mid-summer - not a serious pest	- each larva destroys one seed	- Sx

M. thujae

Larvae	Damage	Species affected
- orange - feed beneath cone scales - move about cone and so may damage more than one seed - form cocoons in the cone during August and early September	- destruction of both scales and seeds	- Cw

***Megastigmus* spp. (seed chalcids)**

Larvae
- white, curved
- one larva develops per seed, devouring the seed's contents in the process
- mature larva overwinters in the seed
- adults emerge by boring a small round hole in the seedcoat

Damage
- no external evidence of damage other than small borehole in seedcoat
- seed contents devoured

Species affected
- Ba, Bg, Bl, Fd, Hw, Sx

***Pityophthorus orarius* (Douglas-fir twig mining beetle)**

Damage
- adults and larvae mine and kill young twigs, affecting next year's cone crop

Species affected
- Fd

***Resseliella* spp. (cone scale midge)**

Larvae
- yellowish-orange
- feed singly or in groups on the surface of cone scales
- do not feed on seeds directly
- larvae overwinter in the litter

Damage
- scales darken prematurely, or if the attack is severe scales may die, killing the seeds indirectly
- generally not extensive

Species affected
- Bg, Py

DISEASES

Caloscypha fulgens (seed fungus or cold fungus)

This seed-borne fungus is spread from diseased to healthy seeds during stratification and when seeds are sown in cold soils. Cones that have been in contact with an infected forest floor, or that have been collected from squirrel caches, often contain infected seeds. During stratification, a whitish-grey mycelium forms on the seedcoat and eventually penetrates the seedcoat, mummifying the contents. This fungus may survive inside killed seeds for several years.

Damage
- seeds appear to be sound, but are mummified and will not germinate

Species affected
- Bg, Fd, Sx, Ss

Chrysomyxa spp. (cone rusts)

Pyrola spp. and *Moneses uniflora* are the alternative hosts for this rust fungus. Spores are wind disseminated in spring or early summer and infect young spruce cones. As the cones dry out, in mid- to late-summer, yellow-orange spores are released.

Damage
- in mid- to late-summer, cones become light brown, dry and open prematurely in the area of infection
- cones may be either completely or partly infected
- seed yields are substantially reduced
- if seeds do develop, cone malformation often prevents their extraction
- if extracted, seeds from infected cones have reduced or abnormal germination

Species affected
- Sx, Ss

APPENDIX 3 Basic Cone Collection Equipment Checklist*

- ❑ Altimeter
- ❑ Axe and/or chainsaw plus fuel and file
- ❑ Binoculars
- ❑ Cone sacks
- ❑ Cone cleaning and inspection table
- ❑ Cone volume measure
- ❑ Cone collectors' report forms (FS 721)
- ❑ Cone cutter (or strong knife)
- ❑ Flagging tape
- ❑ First aid kit
- ❑ Hand cleaner and rags
- ❑ Hand lens (10X)
- ❑ Hard hat
- ❑ Map
- ❑ Plastic pails
- ❑ Razor blades or scalpel
- ❑ Strong twine
- ❑ Spray paint
- ❑ Shipping tags
- ❑ Signalling device (whistle, horn, etc.)
- ❑ Tarpaulins or polythene sheets
- ❑ Tally/note book
- ❑ Water

* Readers contemplating specialized cone collection techniques, such as climbing or aerial clipping, should refer to the appropriate manuals for specific equipment requirements.

APPENDIX 4 Regulations Pertinent to the Collection of Cones of B.C. Conifers

B. C. Reg. 284/82
O. C. 1282/82

Filed July 9, 1982

Forest Act

TREE CONE AND TREE SEED REGULATION

[includes amendments up to B. C. Reg. 147/88]

[Consolidated June 30, 1988]

Interpretation

1. (1) In this regulation

"dealer" means a person, other than an employee of the Ministry of Forests, engaged in the buying and selling of cones or seeds as a business enterprise, and includes a processor;

"licence" means an agreement in the form of a forest licence, timber sale licence, timber licence, tree farm licence, woodlot licence or timber sale harvesting licence entered into under the *Forest Act* or the former Act;

"process" and **"processing"** means every form of treatment of cones and seeds and includes drying, kilning and tumbling of cones and dewinging and cleaning of seeds;

"processor" means a person engaged in processing, but does not include an employee of the Ministry of Forests;

"provenance" means the geographic source or place of origin, including elevation of cones and seeds;

"seedlot" means a quantity of cones or seeds having uniformity of species, provenance, quality and year of collection.

(2) A reference in this regulation to cones or seeds is a reference to the cones, seeds or fruits of any species of commercial forest trees growing in the Province.

Collection

2. (1) Subject to subsection (2), no person shall collect cones or seeds from Crown land unless he holds a cone collection permit issued by a regional manager or other person authorized by him to issue it.

(2) Subsection (1) does not apply to employees or agents of

(a) the Crown.

(b) ***Repealed.*** [B.C. Reg. 147/88.]

(3) A permit issued under subsection (1) may be in Form 1 and

(a) must contain a description of the area of land to which it relates,

(b) may confer rights and be granted subject to obligations referred to in the permit, and

(c) may require, as a condition of issuance, that the holder submit a cone collector's report or a seed orchard cone collection and cost report in a form approved by the chief forester.

(4) A permit to collect cones and seeds from Crown land held under licence or lease shall not be issued unless the licensee or lessee consents in writing to the collection.

[am. B.C. Reg. 147/88.]

June 30/88

Registration

3. (1) It is the duty of the Ministry of Forests to

(a) maintain a register of seedlots,

(b) enter in that register particulars of every seedlot accepted for registration, and

(c) issue a notice of registration for each seedlot so accepted.

(2) A person seeking to have a seedlot registered shall submit an application for registration to the seed centre of the Ministry of Forests and the application must be accompanied by

(a) a sample of the seedlot, or

(b) a completed cone collector's report or seed orchard cone collection and cost report, or sufficient information to complete either of those reports.

Processing

4. (1) A processor shall not process cones or seeds collected from Crown land unless there is deposited with the processor at the time of delivery of the cones or seeds

(a) a cone collector's report or a seed orchard cone collection and cost report, or

(b) evidence of registration of the seedlot.

(2) Except with the consent of the chief forester, no person shall remove from the Province for processing cones or seeds collected from

(a) Crown land, or

(b) seed orchards on private lands which are subject to a management agreement with the Crown.

Disposition

5. (1) No dealer shall buy, sell or trade in cones or seeds unless he is the holder of a seed dealer's licence issued by a regional manager or person authorized by him.

(2) Every dealer shall maintain within the Province a ledger containing, in respect of each transaction in cones or seeds,

(a) the name and address of the vendor and purchaser,

(b) the date of the transaction,

(c) the species of cone or seed,

(d) the volume of cones or mass of seeds, and

(e) the seedlot registration number, cone collection permit number or any other identifying number, or, when the cones or seeds have been collected from land other than Crown land, the name and address of the owner of that land.

(3) The chief forester or his agent has power to inspect and make copies of the ledger at any reasonable time.

(4) A seed dealer's licence may be in Form 2.

June 30/88

Offences

6. Any person who

(a) contravenes section 2 (1), 4 or 5 (1) or (2),

(b) fails to comply with a condition of a permit or licence issued under this regulation, or

(c) obstructs or impedes the chief forester or his agent in carrying out his duties under section 5 (3),

commits an offence.

Ministry of Forests

FORM 1

CONE COLLECTION PERMIT

PERMIT NO

_____ of _____

is hereby authorized under B.C. Regulation _____ to collect cones and seeds from:

Crown lands described as follows:

of Land District

Licence/Lease No. _____ Cutting Permit _____

Block or Unit No. _____ Location _____

and subject to the following conditions:

1. Cones or seeds shall be collected only from the Crown lands described above.

2. In the case of Crown land held under licence or lease, the written permission of the licensee or lessee or their agent must be obtained.

3. Cones or seeds may be collected only from the following species of trees

_____

_____

4. This permit is valid from the date of issue until midnight _____ 19 __.

5. Cones or seeds shall be collected only by means of, or from:

Climbing trees

Felling trees of the above species

Other (specify) _____

May 31/87

6. Branches or foliage may/may not be cut from standing trees for the purpose of collecting cones or seeds therefrom under this permit.

7. Slash and debris resulting from the felling of trees or cutting of branches or foliage shall be disposed of at the permittee's expense by
_____
_____

8. Merchantable logs resulting from the felling of trees for the purpose of collecting cones or seeds therefrom under this permit shall be disposed of by
_____
_____

9. The permittee shall, not later than 7 days after the expiry date of the permit, report to the person issuing the permit, the volume (in hectolitres) of cones or the mass (in kilograms) of seeds of each species collected under this permit.

10. Cones or seeds collected under this permit will be delivered to
_____

11. The permit may be suspended during any forest travel restriction covering the permit area.

12. The permit is subject to immediate cancellation for contravention of any of the above conditions, or for unwarranted damage to the forest.

Forest region _____ _____ Forest Officer
District _____ _____ 19___.
(date of issuance)

I have read and understand the terms and conditions of this permit and the regulations governing the collection of cones and seeds.

PERMIT ISSUED FREE OF CHARGE _____ Permittee

[en. B. C. Reg. 364/82.]

May 31/87

Ministry of Forests

FORM 2

SEED DEALER'S LICENCE

Licence No.

_____,
(Name)

of_____
_____
(Address)

is hereby licensed to purchase, sell or otherwise trade in tree cones and tree seeds subject to the provisions of the Tree Cone and Tree Seed Regulation, and the following conditions:

1. This licence may not be sold or transferred.

2. This licence is valid from the date of issue below.

3. This licence is subject to cancellation where the dealer
   (a) fails to comply with the conditions of this licence,
   (b) fails to comply with sections 4 and 5 of the Tree Cone and Tree Seed Regulation, or
   (c) obstructs or impedes the chief forester or his agent in carrying out their duties in section 5 (3) of the Tree Cone and Tree Seed Regulation.

_____ 19 __ _____
Date Chief Forester

THIS LICENCE IS ISSUED FREE OF CHARGE

[Provisions of the *Forest Act* relevant to the enactment of this regulation: section 158 (2) (k)]

Queen's Printer for British Columbia©
Victoria, 1988

SECTION 33

AIRCRAFT OPERATIONS

Scope

33.00. This section covers the use of aircraft in support of industry and includes the use of aircraft as a means of lifting, transporting, and landing loads and workers.*

*The crewing, maintenance, and operation of aircraft are governed by Department of Transport (Canada) regulations.

Pre-job planning

33.02. Operational procedures, including the selection of aircraft and equipment, shall be planned comprehensively and in detail by qualified persons. Where special circumstances exist, or when directed to do so by the Board, written plans or procedures shall be available to all persons directly concerned.

Aircrew

33.04. Crews of aircraft engaged in airlifting operations shall be qualified in the type of work involved.

Pre-job instruction and training

33.06 All persons involved shall be given adequate pre-job instruction and, where necessary, trial operational training before actual operations commence.

Job supervision

33.08. All operations shall be conducted under the direction of qualified persons.

Emplaning and deplaning

33.10. Emplaning and deplaning from aircraft in flight shall be undertaken only with the prior approval of the Department of Transport (Canada).

Work prohibition

33.12. No worker shall be on any load supported or suspended from an aircraft in flight.

31/1/85

HELICOPTER OPERATIONS

General requirements

33.14 (1) Pilots of helicopters utilized for aerial construction, demolition, erection, dismantling, and the associated transport of workers or materials, shall have:

(a) a commercial, senior commercial, or airline transport helicopter pilot's licence endorsed for the type of aircraft being used, and

(b) a minimum of 500 hours flying time as pilot-in-command of helicopters.

(2) Whenever approaching or leaving a helicopter with blades rotating, all workers shall remain in full view of the pilot and keep in a crouched position. Workers shall avoid the area from the cockpit or cabin rearward unless authorized by the pilot and should not approach from uphill nor depart in an uphill direction.

Communications

33.16. (1) No airlift operation shall be initiated without effective clear channel radio communication between pilots and supervisors of all workers involved in the operation. Alternative hand signals shall be rehearsed in advance but shall be used only to complete an operation in the event of radio failure when the aircraft has been committed to a point which precludes termination of the operation.

(2) Workers who are in two-way radio contact with pilots, shall be identified by wearing fluorescent red vests or jackets.

(3) In structural erection or dismantling, where existing conditions adversely affect communications between the supervisor and the crew handling the airlifted load, designated crew members shall wear receivers on which they can hear radio communications to and from the pilot.

Personal protective equipment

33.18. Appropriate personal protective equipment, including head, hearing and eye protective devices as required by Section 14, shall be worn by workers employed in proximity to operating helicopters.

Grounding

33.20. Workers shall not touch an airlifted load or any part of its rigging until accumulated static electricity has first been discharged to ground.

Assembly yards, landings and work sites

33.22. (1) Material assembly yards, landing areas and work sites shall be located at a safe distance from trees, poles, power lines and other obstructions, and shall be kept clear of:

(a) slipping and tripping hazards, and

(b) excavated materials or other obstructions, which could endanger workers during placement of airlifted loads.

(2) In all work areas exposed to rotor downdrafts:

(a) equipment and materials shall be secured against dislodgement, and

(b) effective measures shall be taken to control dust and prevent loose materials from becoming airborne.

Load release devices

33.24. Helicopters shall be equipped with both electrically and mechanically operated load release mechanisms, to permit instant release of the load in an emergency. Automatic load release mechanisms shall not be armed while handling loads over workers.

Rigging

33.26. (1) All rigging shall be in conformity with the requirements of Section 54.

(2) Tag lines shall be of a length that will not permit their being drawn up into rotors.

Work procedures

33.28. Workers shall keep clear of airlifted loads except for those workers directly involved in handling and securing the loads.

Design factors for landing or touching down helicopters on structures

33.30. Where it is intended that helicopters will emplane or deplane workers or material onto or from a structure, there shall be provided, by January 1, 1980, a suitable touch-down or landing surface that ensures stability for the helicopter and safe footing for workers. The extent of the surface to be used for touch-down or landing shall be defined and the permissible loading certified by a registered professional engineer. The area and the permissible loading shall be marked upon the structure so as to be clearly visible to the pilot or the pilot shall be provided with the information in writing.

Operational procedures for landing or touching down helicopters on structures

33.32. At the discretion of the pilot-in-command, workers or material may be emplaned or deplaned onto or from a structure subject to the following minimum conditions:

(a) Where the surface prescribed by regulation 33.30 is installed the employer of the workers involved shall obtain permission in writing from the owner of the structure. The pilot shall be provided with this information in writing.

(b) Landing or touching down on a structure where the provisions of regulation 33.30 do not ordinarily apply, and to other structures before January 1, 1980, is permitted providing that the employer of the workers involved is in possession of permission in writing from the owner of the structure, and of certification signed by a registered professional engineer as to the permissible safe loading, with definition of the portion of the structure covered by the certificate. The pilot shall be in possession of this information in writing.

(c) The helicopter shall place sufficient weight on the structure to provide aircraft stability.
(d) The skids shall be, whenever possible, of the lowest configuration. They shall extend sufficiently beyond the supports upon which they are to rest to preclude entanglement.
(e) "Bear paws" shall be removed.
(f) Hinged doors for access or egress shall be removed, sliding doors locked back, and adequate handholds shall be provided when workers are emplaning or deplaning onto or from elevated structures.
(g) Safe access and egress routes shall be available and used by the workers.
(h) Workers shall be safely positioned before the helicopter touches down, lands, or lifts off.

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Plant Protection Act

BRITISH COLUMBIA BALSAM WOOLLY APHID REGULATION, 1976

1. This regulation may be cited as the "British Columbia Balsam Woolly Aphid Regulation, 1976".

2. (1) Anyone wishing to grow Abies spp. in British Columbia must obtain an annual permit from the B.C. Ministry of Agriculture and Food.

(2) Anyone who is granted a permit under subsection (1) to grow Abies spp. must treat such trees for balsam woolly aphid control in a manner specified by the Minister of Agriculture and Food.

(3) All trees of Abies spp. offered for sale or moved from the nursery must bear a B.C. Ministry of Agriculture and Food tag showing that they have been grown under permit.

3. Abies spp. originating within the infested zone are prohibited movement to areas in British Columbia outside the infested zone.

4. The infested zone is described by B.C. Forest Service Ranger District boundaries and includes the following portions of the Vancouver Forest District:

RD 1 - Cultus Lake,
RD 3 - Harrison Lake,
RD 4 - Mission,
RD 5 - Port Moody,
RD 6 - Squamish,
RD 7 - Sechelt,
RD 8 - Pender Harbour,
RD 9 - Powell River,
RD 19 - Parksville, that portion south of a line between Parksville and Port Alberni,
RD 21 - Duncan,
RD 23 - Langford,
RD 24 - Lake Cowichan,
RD 25 - Port Alberni, that portion southeast of Alberni Inlet.

5. Sale and movement of cut trees or foliage of Abies spp. is prohibited between January 31 and November 1 anywhere in British Columbia.

6. The sale and movement of cones and seeds of Abies spp. is permitted anywhere in British Columbia.

7. Retail outlets offering Abies spp. for sale which are found by an inspector to have infested trees shall immediately treat the trees in a manner specified by an inspector or the inspector may order the destruction of the infested trees.

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8. Inspectors appointed under the Provincial Plant Protection Act and the Federal Plant Quarantine Act are empowered to enforce the provisions of this regulation.

9. Where an inspector is of the opinion that this regulation or the intent of this regulation is being contravened,

(a) he may serve upon that person who is responsible for such contravention a written notice of the contravention ordering that person to do such things as the inspector may order for the purpose of preventing any similar or further such contravention,

(b) every person who neglects or refuses to comply with the order of an inspector contained in a notice under paragraph (a) is guilty of an offence, and

(c) where an inspector takes any action under paragraph (a) he shall, forthwith after the action is taken, give to the Head, Entomology Branch, a report of his actions.

10. Every person who contravenes any of the provisions of this regulation is guilty of an offence and is liable, on summary conviction, to a fine not exceeding $100 or to imprisonment for a term not exceeding 6 months, or to both fine and imprisonment and, in addition, the stock may be destroyed.

[Provisions of the Plant Protection Act relevant to the enactment of this regulation: section 3]

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